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The Construction and Testing of the Milwaukee Refuse Incinerator.

By SAMUEL A. GREELEY,* Jun. Am. Soc. C. E.

Within the past two months the officials of the city of Milwaukee have put into operation a refuse incineration plant having a rated capacity of 300 tons of mixed refuse per 24 hours.

For the last ten years, garbage in Milwaukee has been burned at a garbage crematory located on Jones Island, near the entrance to the harbor. [See Eng. News, Jan. 23, 1902, for illustrated description.—Ed.] This crematory has a rated capacity of 120 tons a day. The plant is divided into three units, with space in the building for a fourth, the chimney being located at the center. The furnaces are fitted with drying tables for the garbage and with coal grates for adding the necessary coal for combustion. Already the capacity of the plant has been reached and there is no spare unit to carry the load when repairs are needed. The plant was unfortunately built with poor foundations, and consequent settlement has caused the furnace structures to deteriorate. It is probable that considerable repairs would be necessary to keep the plant in operation for another six years. Already these have amounted to over $2,000 per year. Furthermore, this plant is so located that most of the garbage has to be transported to it across the Milwaukee River on barges. This is difficult during the winter months on account of the ice in the river. Consequently during the winter months it has been necessary to dispose of a large part of the garbage at a farm northwest of the city. The roads over which the garbage was hauled to this farm are sometimes in very poor condition, and the collection system has been handicapped on this account. It is uncertain for how long a time a farm, even as accessible as the one recently used, will be available. Furthermore, the cost of disposal at the old plant was high amounting, in 1909, to $1.37 per ton of garbage, according to the records of the health department. The overtaxed capacity of the Jones Island crematory, its condition of rapid deterioration, the high cost of disposal due to the coal required, the transportation costs and the difficulties attending collection and disposal of garbage during the winter, made it necessary for the officials of Milwaukee to provide other means for its disposal.

With this in view, the city officials engaged Mr. Rudolph Hering, M. Am. Soc. C. E., of New York, to advise with them upon the question of refuse disposal. Based upon Mr. Hering's investigation and recommendations, the city proceeded to the construction of a refuse incineration plant located on the mainland, near the entrance to the harbor and across the river from the old plant. This plant, having a daily capacity of 300 tons, is as large a plant as could properly be built in one place, on account of the length of haul required to reach it. Already this feature has become burdensome. The logical thing for the city to do ultimately is to provide other incinerators in the southwest and northwest sections of the city, thereby reducing the length of haul by about one-half. For the present the new refuse incinerator has been designed to burn the garbage, separately collected, from the whole city, together with sufficient ashes and rubbish from certain districts to give a combustible grade of refuse. After additional plants are built, the garbage will be divided among each of them, so that the grade of refuse burned at each plant would approximate the normal grade of refuse produced by the city. This development of the system now begun would probably lead to the mixed collection of all refuse instead of the separate collection now in use.

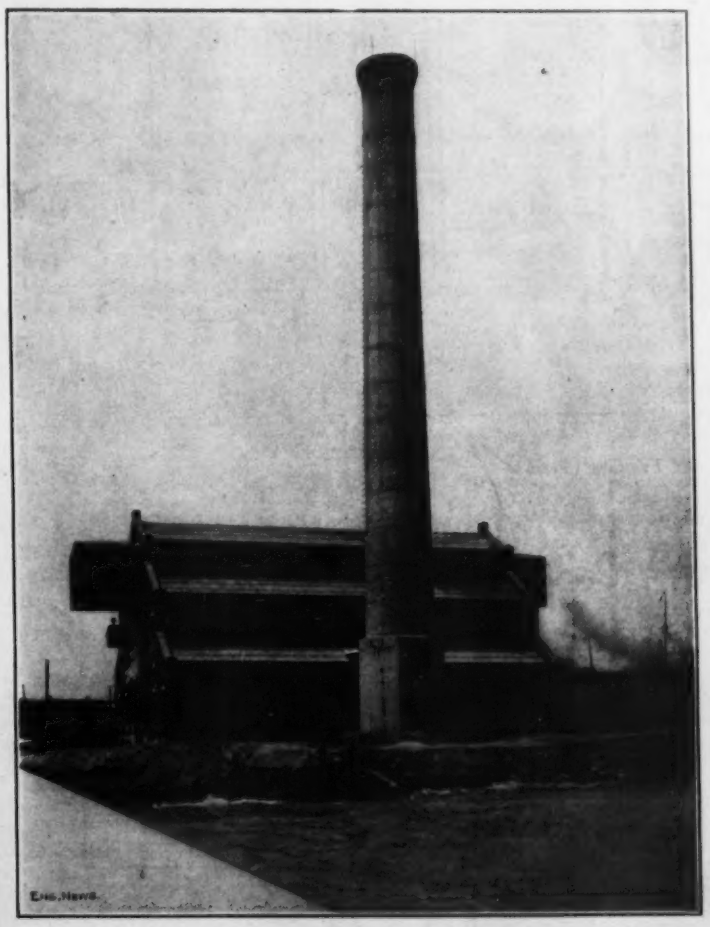


FIG. 1. GENERAL VIEW OF REFUSE INCINERATOR PLANT, MILWAUKEE, WIS.

(The view shows refuse being hoisted; also the clinker dump on the lake shore.)

Design and Character of the Plant.

Figs. 1 to 5 show the general design and some of the details of the new plant. The specifications and the results of bidding have already been published in Engineering News for April 22, 1909. As a result of these bids, construction work was started on April 24, 1909. The first fires were started on April 14, 1910, and the plant has been in full operation since May 12, 1910.

The new plant was built under the direction of the Board of Public Works, after general plans and specifications prepared by Hering & Fuller, Consulting Engineers, 170 Broadway, New York City. The writer was the resident engineer on the works, representing Hering & Fuller. Mr. Hering had the general oversight of the work during the period of construction and testing.

As already stated, the plant was designed to burn mixed refuse, consisting of the garbage from the whole city, and ashes and rubbish from the first seven wards, and sufficient manure to give the total daily quantity. Experience in the past has shown that stable owners have considerable difficulty in disposing of manure, and for this purpose the new plant is designed to handle a certain portion of this class of refuse.

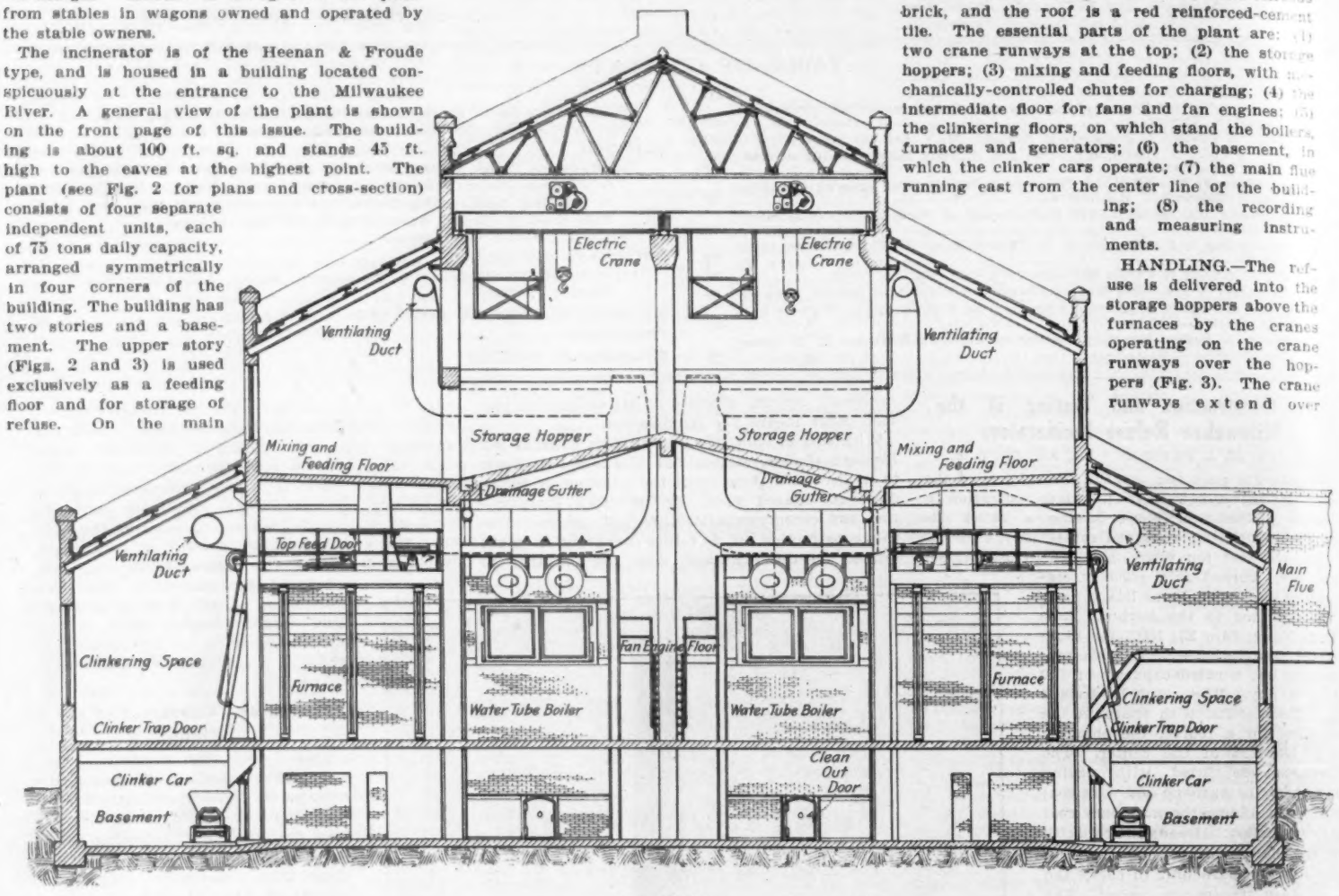
Garbage is now collected separately in steel boxes resting on four-wheeled frames, drawn by one horse, each box having a capacity of 1¼ cu. yds. From 185 to 225 loads of garbage are collected each day. The ashes and rubbish are collected separately or together, as they are found, in bottom-dumping wagons holding about 3 cu. yds. and drawn by two horses. Although it was originally contemplated that the ashes and rubbish from the first seven wards only should be delivered to the incinerator, it has been found

*Superintendent Refuse Incinerator, City Hall, Milwaukee, Wis.

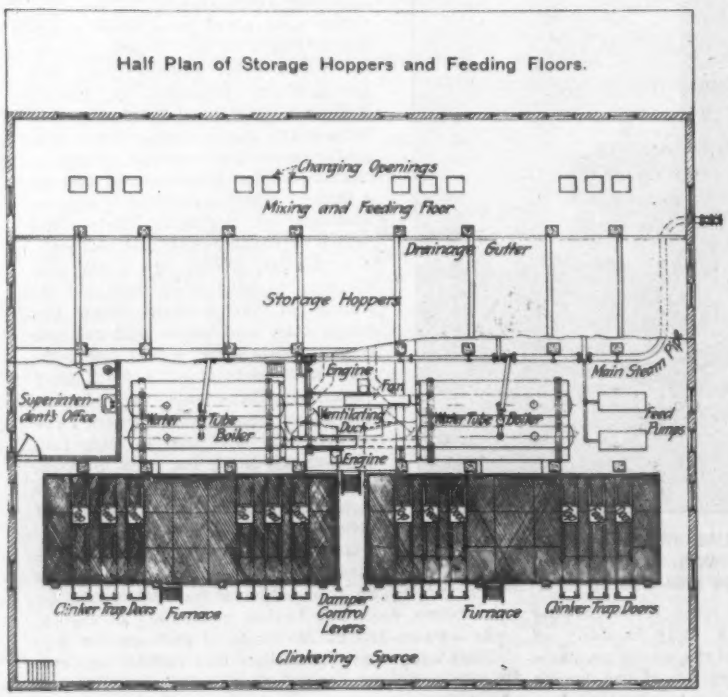
advisable during the summer to haul this material from three additional wards within convenient hauling distance. This flexibility in the amount of ashes and rubbish delivered to the plant is a feature of the separate collection worthy of comment as offsetting some of its disadvantages. Manure is brought to the plant from stables in wagons owned and operated by the stable owners.

The incinerator is of the Heenan & Froude type, and is housed in a building located conspicuously at the entrance to the Milwaukee River. A general view of the plant is shown on the front page of this issue. The building is about 100 ft. sq. and stands 45 ft. high to the eaves at the highest point. The plant (see Fig. 2 for plans and cross-section) consists of four separate independent units, each of 75 tons daily capacity, arranged symmetrically in four corners of the building. The building has two stories and a basement. The upper story (Figs. 2 and 3) is used exclusively as a feeding floor and for storage of refuse. On the main floor (Figs. 2 and 4) the chief work, such as clinkering and operating the plant, is done. The basement is used for the clinker railway and for cleaning out the dust from the furnaces and boiler settings. The radial brick chimney, 10 ft. in diameter at the top, is located east of the building, about 20 ft. from the wall. The building and chimney both stand on pile foundations, above which are the concrete basement walls and the superstructure framework of reinforced concrete, which consists of columns, floors, storage hoppers and crane runways. The enclosing walls of the building are a red, semi-vitreous brick, and the roof is a red reinforced-cement tile. The essential parts of the plant are: (1) two crane runways at the top; (2) the storage hoppers; (3) mixing and feeding floors, with mechanically-controlled chutes for charging; (4) the intermediate floor for fans and fan engines; (5) the clinkering floors, on which stand the boilers, furnaces and generators; (6) the basement, in which the clinker cars operate; (7) the main flue running east from the center line of the building; (8) the recording and measuring instruments.

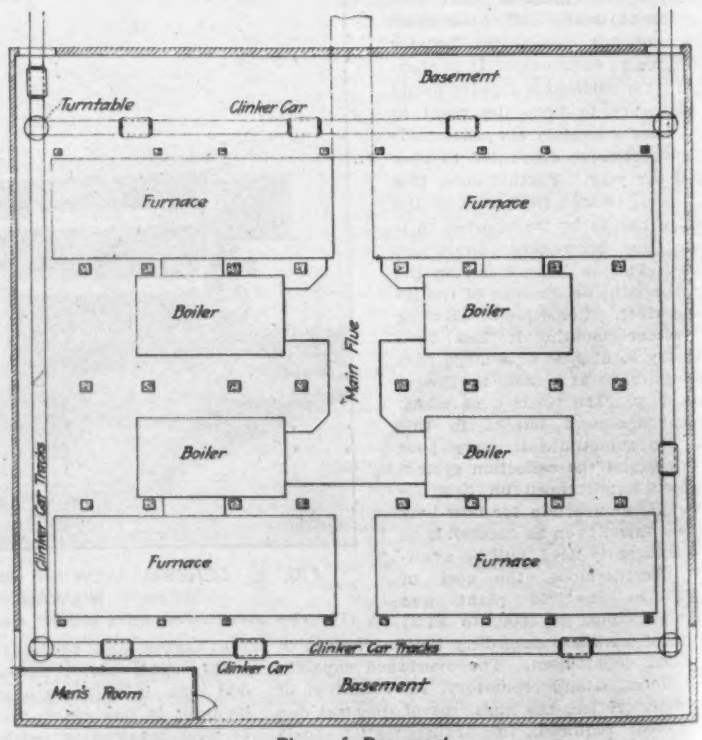
HANDLING.—The refuse is delivered into the storage hoppers above the furnaces by the cranes operating on the crane runways over the hoppers (Fig. 3). The crane runways extend over



Cross-Section.



Half Plan of Furnaces and Clinkering Floor.



Plan of Basement.

FIG. 2. MAIN AND BASEMENT PLANS AND CROSS-SECTION OF REFUSE INCINERATOR, MILWAUKEE, WIS.

the roadways outside of the building at the north and south ends (front page view). The garbage wagons come to the north end, where the cranes lift the movable steel box and deposit its contents into the hopper. At the south end of the building four dumping pits have been built in which stand steel dumping boxes. The city ward wagons hauling ashes and rubbish are of the bottom-dumping type. They back in over the dumping pits and deposit their loads into the dumping boxes, after which the crane lifts the dumping boxes and deposits their contents into the storage hoppers. Garbage is delivered to the plant between 4.30 and 9.30 a. m., and ashes and rubbish between 9 a. m and 5 p. m. Manure comes at odd times as convenient for the stable owners. The garbage boxes and dumping boxes have been fitted with an attachment at the end which, at the top of the hoist, engages a fixed hook on the crane trolley. After the hook has engaged the attachment, the craneman lowers on his hoist and the box swings into a vertical position to empty. About 20 garbage boxes can be handled per hour and about 15 refuse boxes.

FIG. 3. INTERIOR VIEW OF MILWAUKEE REFUSE INCINERATOR PLANT, SHOWING REFUSE IN STORAGE HOPPERS, OVERHEAD TRAVELING CRANE FOR DUMPING REFUSE IN HOPPERS, AND VENTILATING DUCT.

STORING.—The storage hoppers (Figs. 2 and 3) are built symmetrically about the center lines of the building. There are three compartments for each of the four furnace units. All of the hoppers drain, with a slope of 1 to 4, from the center line of the building to gutters at the foot of the slope near the feeding room floor. At the present time a mixture of garbage, ashes and rubbish is being deposited in the two outside compartments of each furnace, the middle compartment being reserved for storage of manure and the excess supply of ashes. The drains at the bottom of the hoppers have proved to be a very necessary part of the plant, because the garbage, under the weight of a pile 6 or 7 ft. high, squeezes out a large amount of water. The total storage capacity is about 550 cu. yds., amounting to about 300 tons, or about one day's supply.

CHARGING.—Extending from the gutters at the bottom of the hoppers to the building wall is the charging room floor, or feeding and mixing room floor. The charging chutes (see plan, Fig. 2) to the furnaces open about an inch above the level of these floors. The refuse is raked and shoveled out of the storage hoppers into these charging chutes. As each charging chute is filled, the workman grades the refuse to suit the condition of the fire. This feature is one of considerable importance, as it enables a poor fire to be picked up rapidly with an ignition charge after clinkering. There are six charging chutes for each furnace, one for each of the six grates. Each charging chute is of sheet steel, 6 ft. long, 18 × 24 ins. at the top and 24 × 30 ins. at the bottom, and they hold about 1 cu. yd. of refuse. At the bottom of the chute is a mechanically-controlled door which the fireman operates from the floor, in front of the furnace (see cross-section, Fig. 2, and view, Fig. 4). This device consists of two steel shafts attached to four pinion wheels rolling in pairs on two racks. The shafts hold a fire-brick door and are attached eccentrically to the pinions, so that when the pinions are pulled forward they lift the door from its seat and carry it forward at the same time. Guides to prevent the falling refuse from spilling follow the door as it moves away from the chute. It requires less than 30 seconds to open and close one of these doors. So far there has been no indication at all of refuse jamming in the chutes. The door itself consists of a cast-iron frame filled with fire-brick blocks. The outer edges of the frame extend below the fire-brick and fit snugly into cast-iron seal-troughs filled with asbestos packing to seal the door tightly. When going at rated capacity, about nine charges of refuse are put into each furnace per hour. The charge of refuse does not fall directly onto the grate, but onto a drying hearth at the back, thus preserving the activity of the fire.

FURNACES.—On the main floor of the plant, generally spoken of as the clinkering floor, the four furnace units are located. These are arranged symmetrically about the center lines of the building. Each unit consists of the furnace chamber proper, a water-tube boiler, an air heater and the forced-draft apparatus. The furnace chamber consists of the steel framework holding the brick walls and arches. Within each furnace are six grates or cells, divided at the center into groups of three by a common combustion chamber. At the back of the furnace are two ducts, the hot gas duct above and the hot air duct below. In front of the hot gas duct, and separated from it by a 9-in. fire-brick wall, is the so-called drying hearth. The grates extend from the drying hearth to the dead plate in front of the clinkering door. Below each grate is a separate ash pit so that the forced draft for each grate can be separately controlled. The general arrangement of the several parts of the furnaces, and the course of the air supply and gases of combustion, are shown by Fig. 5, which, however, is not strictly accurate as to structural details.

The gases of combustion from the grates come together in the large combustion chamber, where their velocity is checked and they are turned slightly downward by a baffle wall at the top. This not only gives ample opportunity for complete combustion of the gases, but has a decided tendency to deposit the dust from the gases into the lower part of the combustion chamber, which is carried about 10 ft. below the grate level. From the combustion chamber the gases enter the first and second passes of the boiler, then pass through the inside of the tubes of the air heater, and then through a short flue into the main flue and so to the chimney. In the short flue there is a damper which controls the suction draft for each unit.

The forced draft for combustion is driven by fans around the outside of the tubes of the air heater and into the hot air duct, from which it passes through valves into the ash pits, and so through the perforated grate bars to the fire. The hot gas duct above the hot air duct is operated by steam jets, which induce the hot gases from the combustion chamber through openings in the brickwork into the refuse standing on the back hearth. The purpose of this is to partly dry out the abnormally wet refuse as it stands on the back hearth before it is raked over on the fire.

The back hearth receives the fall of the refuse from the charging chutes above and is built of a specially heavy design for this purpose. The refuse is left to stand and dry on this hearth until it is needed on the fire, when it is raked forward by the firemen.

The grates slope slightly from the back hearth to the furnace front and are built of heavy cast-iron channels perforated with ½-in. holes for the admission of the draft. They rest freely on the dead plate of the furnace front and can slide forward and back on this as they expand and contract.

The furnace fronts are built of heavy castings secured to the vertical and horizontal steel framework of the furnace. In front of each grate is a wide clinkering door, in which is a small stoking door, which gives the stoker a good rest for his rake when raking new refuse over the fire. The ash pit door closes the ash pit practically gas tight, and the valve controlling the forced draft operates through the furnace front just above the ash pit door.

BRICKWORK.—The furnaces and boilers are built of a pink pressed brick, lined with fire-brick, and are heavily braced with steel buck stays and horizontal channel irons. After a thorough investigation, three grades of fire-brick were selected, as follows: (1) C. Franklin Crown, a tough, hard, close-grained brick, used to line the sides and doors of the furnaces, and selected especially to withstand the wear and tear from stoking and clinkering. (2) Royal Star, a softer, coarse-grained, highly refractory brick, used in the arches of the furnaces where the heat is greatest. (3) Scioto Star, a good refractory boiler brick used to line the second pass of the boilers and the flues. These brick have the following chemical analyses:

CHEMICAL ANALYSES OF FIRE BRICK.

	C. Franklin Crown.	Royal Star.	Scioto Star.
Silica	53.25	55.25	56.17
Aluminum	41.01	41.78	40.86
Iron oxide	3.36	1.67	1.53
Lime	.41	.267	.289
Magnesia	.47	.501	.525
Alkali	1.50	.530	.618

Tests of these brick were made with the following results:

TESTS OF FIRE BRICK.

	Absorption in 48 hrs.	% Elongation at 1,800° F.
C. Franklin Crown	6.93%	0.4%
Royal Star	8.64%	0.67%
Scioto Star	7.0%	1.4%

FIG. 4. INTERIOR VIEW OF MILWAUKEE REFUSE INCINERATOR, SHOWING CLINKERING FLOOR, FURNACE FRONTS AND VENTILATING DUCTS.

The brick were all laid in fire clay, mixed to the consistency of cream. Each brick was dipped in the clay and then hammered into place with a heavy mason's hammer so as practically to touch the surrounding brick on all sides. The maximum space between the bricks thus laid was ⅛-in., but this was due to irregularities in the brick and never extended over the whole bed. The average thickness of joint was less than 1/16-in. It was found advisable to select the brick so that each course should contain brick that was as nearly the same thickness as possible. Bricks burned at the same time should be kept together and used in the same parts of the wall.

The methods of bonding the fire-brick together are interesting. In walls more than one brick thick, the brick were held together by strips of 1/16-in. band iron extending through over two brick, the end of the iron being bent over as a hook at the exposed surface of the brickwork. This was done because a difference in temperature on the two sides of the brickwork would naturally produce different degrees of expansion and contraction. The ordinary header and stretcher bond would have given no opportunity for the brickwork to adjust itself to these movements between the inside and outside courses. In other places where the difference in the expansion between the two sides of the wall was not great, header courses were built in to every three stretcher courses. About the clinkering doors large blocks were used, and were laid to overlap each other so as to prevent the falling out of the brick under the jar of the clinkering.

The arches over the furnaces rest on cast-iron skewbacks built into the furnace wall. Each consists of two independent arches resting on separate skewbacks. The lower arch receives the full heat from the fire and protects the upper arch, which remains intact to hold the roof of the furnace in place. Fig. 7 shows one of the furnace units under construction.

BOILERS.—Each furnace unit contains a 200-HP. water-tube boiler (Fig. 2). These boilers are hung from steel frameworks extending to the concrete footings above the piles. The boilers are hung high so as to provide ample space for dust settling out and for the tubular air heater to stand below the boiler tubes in the second pass. Each boiler is equipped with three dust-blowing doors so that the tubes can be kept free from dust and the evaporation maintained at the maximum. The boiler settings in the basement are all accessible through heavy doors for the removal of dust.

AIR HEATERS.—Below the tubes in the second pass of the boiler stands a tubular air heater. Each heater is approximately 8½ × 8½ ft. in plan and 4 ft. high. It was found during the tests that this was sufficient to pre-heat the forced draft to more than 350° F.

FLUES.—Each furnace unit connects with the main flue through a short trunk flue leading from the boiler setting below the air heater. In this short flue is a damper so that the draft from each unit can be controlled. Each of these trunk flues has an area of about 30 sq. ft. The main flue extends between the furnaces on the east and west center line of the building to the chimney. It has an area as it enters the stack of approximately 65 sq. ft. Just in front of the entrance to the stack is a damper so that the chimney draft can be controlled. The main flue is built of pink dressed brick, lined with fire-brick, the walls being 13 ins. thick. The brick-work is supported on a steel framework and is braced by vertical back stays.

CLINKERING.—The clinkering doors are in the furnace fronts (Figs. 2 and 4). In front of each clinkering door is a so-called clinker trap door, which covers an opening through the clinkering floor into the basement. In the basement clinker cars operate on narrow gage tracks. During clinkering the clinker door and the clinker trap door are opened. The clinker and ash drawn from the grate fall through the trap door into the car standing below. At the present time, clinker is being dumped at the lake shore, about 200 ft. east of the plant.

VENTILATION.—The air for the forced draft is drawn by the fans from the clinkering rooms and from the feeding and mixing rooms (Figs. 2 and 4). Ducts extend from the fans along the tops of the furnace fronts in the clinkering rooms; and also above the charging chutes in the feeding and mixing room. In this way the hot, close air about the furnace is continually drawn out and forced through the fires to the chimney.

FANS.—The forced draft is produced by four 48-in. Sirocco fans, each having a capacity of 10,000 cu. ft. of air per minute under a pressure of 5 ins. of water at the fan outlet. These fans are directly connected to 5-in. high-speed vertical enclosed engines built by the American Blower Co. There is one fan and engine for each unit. These all stand on a small concrete platform above the flue and between the four furnaces. The air is delivered by the fans into ducts leading to the air heaters. By means of a baffle, the cold air passes twice around the

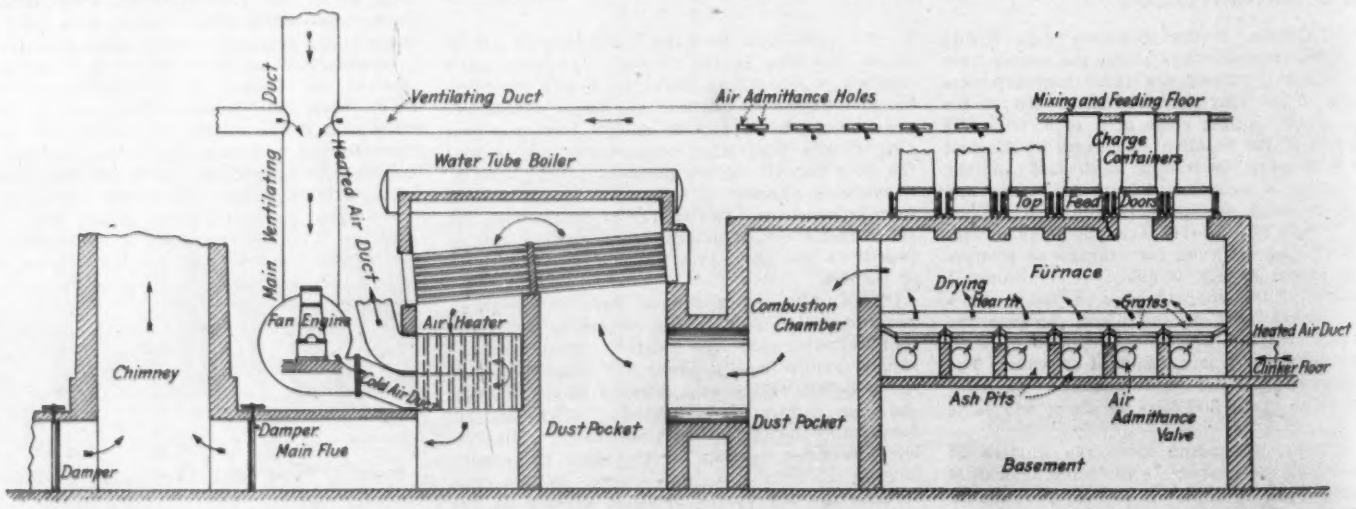


FIG. 5. DIAGRAMMATIC SECTION TYPICAL OF ONE UNIT OF MILWAUKEE REFUSE INCINERATOR, SHOWING COURSE OF AIR SUPPLY AND GASES OF COMBUSTION.

(This section does not fully represent the actual construction, but serves the purpose indicated by the title.)

tubes of the air heater and then passes through a duct to the ash pits. The draft into each ash pit is controlled separately by a valve operated at the furnace front.

CHIMNEY.—The waste gases of combustion all pass into a radial brick chimney standing 154 ft. high above the clinkering floor level. This stack is lined with fire-brick to a height of 55 ft. It has an internal diameter of 10 ft. at the top.

INSTRUMENTS.—The plant is fully equipped with indicating and measuring instruments so that the operation of the furnaces can be watched and maintained at maximum efficiency. This feature is of considerable importance in conjunction with the power plant for the utilization of steam, a feature which is being considered by the city officials. These instruments include the following: a Fery radiation pyrometer, a Bristol electric indicating pyrometer, a CO_2 recorder, thermometer, and draft gages.

SPECIAL FEATURES.—There are several special features to which particular attention should be called. (1) The provision for draining the water from the garbage stored in the hoppers is a feature which takes full advantage of the local conditions of separate collection. It has been estimated that from 7 to 9% by weight of the water in the garbage drains away in this manner.

(2) The central location of the combustion chamber and its extension to the basement 10 ft. below the grate level provides ample opportunity for the settlement of dust and for complete combustion to eliminate smoke. This feature has proven to be very successful.

(3) An objection sometimes made to mechanical charging is that the discharge of a large quantity of refuse at one time into the furnaces destroys the activity of the fire. This objection is obviated by receiving the fall and shock of the charge on the back hearth instead of on the grate. This not only prevents the disturbance of the fire but also affords opportunity for drying the refuse somewhat before actually stoking it over the grate.

(4) The large areas of flues and passages throughout the furnaces, and the complete control of these with dampers, have proven to be features well worth their cost.

Construction of the Incinerator.

CONTRACTS AND PRICES.—The general contract for the foundations and framework of the building and for the furnaces, boilers, machinery, etc., was awarded to the Power Specialty Co., of New York City, for the approximate sum of $175,000. The building and appurtenances were let in twelve separate contracts, amounting altogether to $20,000. The chimney was built by the M. W. Kellogg Co., of New York, for $4,485. The extras on the work amounted to approximately $4,500, and the engineering and inspection fees to approximately $5,000. The total cost of the work has, therefore, amounted in round numbers to $208,985.

RATE OF CONSTRUCTION.—As already stated, the construction work was started on April 24, 1909. The excavation, amounting to a little over 2,600 cu. yds., was completed in two weeks. The driving of 773 piles, each about 44 ft. long, occupied the time from May 7 to June 16. From June until the end of November the concrete foundations, framework, columns, floors, storage hoppers, crane runways, etc., were completed. The building brickwork was started on Sept. 8 and the building walls and roof were completed by Dec. 2, so that work could continue regularly throughout the winter. The boilers were moved into the building during October and November. The furnace steel framework was started on Sept. 18. Brickwork for the furnaces was started the first week in December, 1909, and continued regularly until the middle of April, when fires were started in one of the furnaces and all four of them, together with the main flue, were practically completed. In point of fact, the first furnace was ready for drying out on Jan. 14, and by Feb. 22 fires for drying out had been started in all four units. It required, therefore, about two months' time to complete a furnace ready for drying out, and about two months more to complete a furnace ready for firing at high temperature. During this time, from 60 to 80 masons were employed on the work.

The radial brick chimney was started on July 30, 1909, and was put up in six weeks, no unusual difficulties being encountered.

MATERIALS.—The materials used in the construction were not unusual. The concrete was all made of Hecla Portland cement, bank sand and Wisconsin limestone, mixed in the proportions of 1:2½:5 by volume. Twisted steel rods and corrugated steel bars were used for the reinforcement. The concrete columns had four or eight vertical reinforcing rods, hooped with ¼ and ⅜-in. rods, spaced 12 ins. Special efforts were made to secure a first-class grade of lime-cement-sand mortar for the brickwork of the chimney and furnaces. Precautions were taken not to slack the lime with too much water and to give it ample time to become thoroughly slacked. Special pains were taken to thoroughly mix the lime, sand and cement, and to secure the true proportions of each.

In connection with the care given the mixing of the lime and mortar, the writer made some tests, using different mixtures and lime slacked for different periods of time. These tests indicated that one of the chief elements in securing compressive strength in mortar for brick masonry is the mixing. The more thoroughly the mortar was mixed, the greater was the compressive strength developed. The writer has frequently noticed the careless way in which mortar for brick masonry is prepared. Feeling that in structures like a tall chimney or furnaces subjected to heat the quality of the mortar was of greater importance than in ordinary house construction, the tests were made, and as a result great care in the preparation of the mortar was required. The materials used in the work were tested by Mr. Charles Buckelmueller, city cement tester.

Contract Tests.

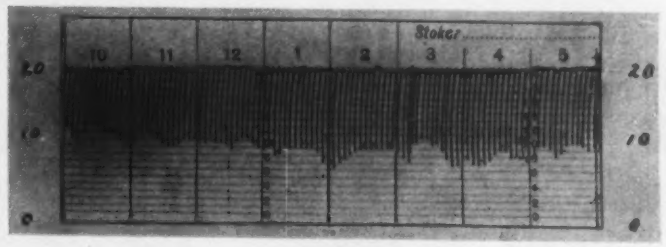
In accordance with the specifications, each unit was tested once. The specifications required that there should be three official tests and one test on a mixture prepared to represent the normal grade of refuse wasted by the city, a condition which will hold when other incinerators have been built. It was determined that this mixture, for the average throughout the year, would approximate the winter mixture defined in the specifications. Consequently tests were made, using only the three mixtures of refuse designated in the specifications as extreme summer refuse, extreme winter refuse and average annual refuse. The results of the three official tests are given in the accompanying table. The fourth test was made as a provisional test before the plant was put into full operation, and proved the capacity and evaporation abilities of the plant satisfactorily.

While the three official tests were being made, the plant was handling all the garbage of the city. This made the conditions of testing rather arduous, because the plant had not had time to develop its best efficiency and because other portions of the plant had to be kept in full operation. Three units were in regular operation during the tests, one at a time being singled out for testing.

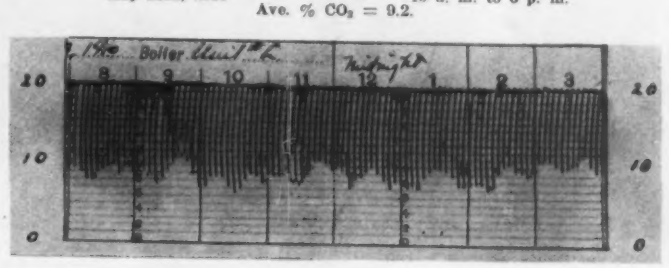
The material burned during the tests consisted of garbage, ashes, rubbish and manure taken from the regular collection wagons. No attempt was made to select any of the materials. Samples were taken during five different tests and analyzed, the results being given in the following table:

ANALYSES OF REFUSE TESTED.

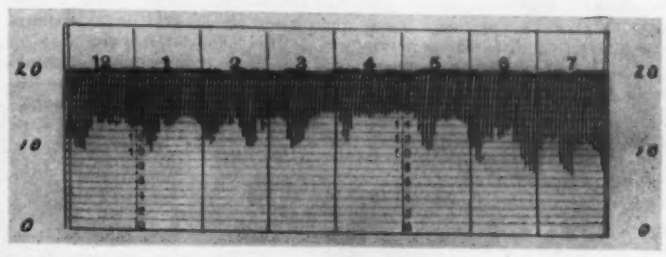
	Moisture.	Carbon.	Volatile matter.	True ash.
	Percentage			
(1) Garbage:				
May 18.....	64.32	4.85	18.95	11.88
" 24.....	68.67	4.22	18.20	8.91
" 26.....	72.44	4.29	16.92	6.35
" 27.....	75.74	3.39	16.49	4.38
June 1.....	71.87	3.95	17.25	6.93
Average	70.6	4.1	17.6	7.7
(2) Ashes:				
May 18.....	15.43	12.75	6.48	65.34
" 24.....	20.20	26.94	4.25	48.61
" 26.....	15.79	23.33	8.76	52.12
" 27.....	19.62	15.24	6.06	59.08
June 1.....	19.12	38.01	3.40	39.47
Average.....	18.0	23.3	5.8	52.9
May 24, Sample of wet ashes.	30.41	19.67	8.41	41.51



May 20th, 1910 — Extreme Summer Refuse. 10 a. m. to 6 p. m. Ave. % CO_2 = 9.2.



May 23rd, 1910 — Extreme Winter Refuse. 8 p. m. to 4 a. m. Ave. % CO_2 = 9.1.



May 27th, 1910 — Average Annual Refuse. 12 m. to 7.45 p. m. Ave. % CO_2 = 13.1.

FIG. 6. CO_2 RECORDS, MILWAUKEE REFUSE INCINERATOR TESTS.

(3) Rubbish:				
May 18.....	13.60	18.21	36.37	31.82
" 24.....	18.03	16.04	29.72	36.21
" 26.....	17.07	16.25	59.63	7.05
" 27.....	50.83	8.90	19.52	20.75
Average.....	24.9	14.9	36.3	23.9
(4) Manure:				
May 18.....	49.29	9.27	27.95	13.49
" 24.....	53.63	11.52	27.78	7.07
	49.57	10.18	33.54	6.71
" 26.....	57.02	10.83	22.65	9.50
" 27.....	58.57	7.34	28.13	5.96
June 1.....	50.50	11.34	33.30	4.86
Average.....	53.1	10.1	28.9	7.9
(5) Street Sweepings:				
June 1.....	33.05	9.31	14.6	43.04

The samples were taken on the dates indicated and were analyzed in the laboratory of the Semet-Solvay Co. The percentage proportions are by weight of the original sample.

Representative shovel-fulls of the materials

were taken, mixed, chopped, halved, quartered and bottled for analysis.

The various ingredients of the refuse were not artificially mixed. The garbage was first deposited on to the floors of the two outer hoppers of the unit under test. Then the ashes, rubbish and manure in the proper quantities were deposited on top of the garbage as they were received from the wagons. While the material for the tests was being weighed and stored in the two outside hoppers, the furnace was being operated by material previously stored in the middle hopper. At a specified time the charging chutes were filled with refuse from the weighed material, and the test was continued until all of the weighed material had been deposited into the charging chutes.

Records of the temperature and evaporation were taken regularly throughout all the tests. Temperatures in the combustion chamber were read on a Bristol electric pyrometer, calibrated to read up to 2,400° F. These readings were taken every 15 minutes. The points of the instrument extended through the sight hole of the combustion chamber door about 3 ft. into the combustion chamber. They therefore did not extend into the hottest part of the furnace, and the readings of temperature are consequently on the safe side. All other readings were taken every half-hour. The measurements were made by the writer, assisted by four men, two of whom were from the city meter testing department, one of whom was electrician at the old garbage plant, and the other of whom was employed especially for this purpose. The Bristol pyrometer was calibrated against three high-temperature instruments at the Semet-Solvay Co.'s plant and was found to be approximately correct. The feed water meter was calibrated at intervals throughout the tests.

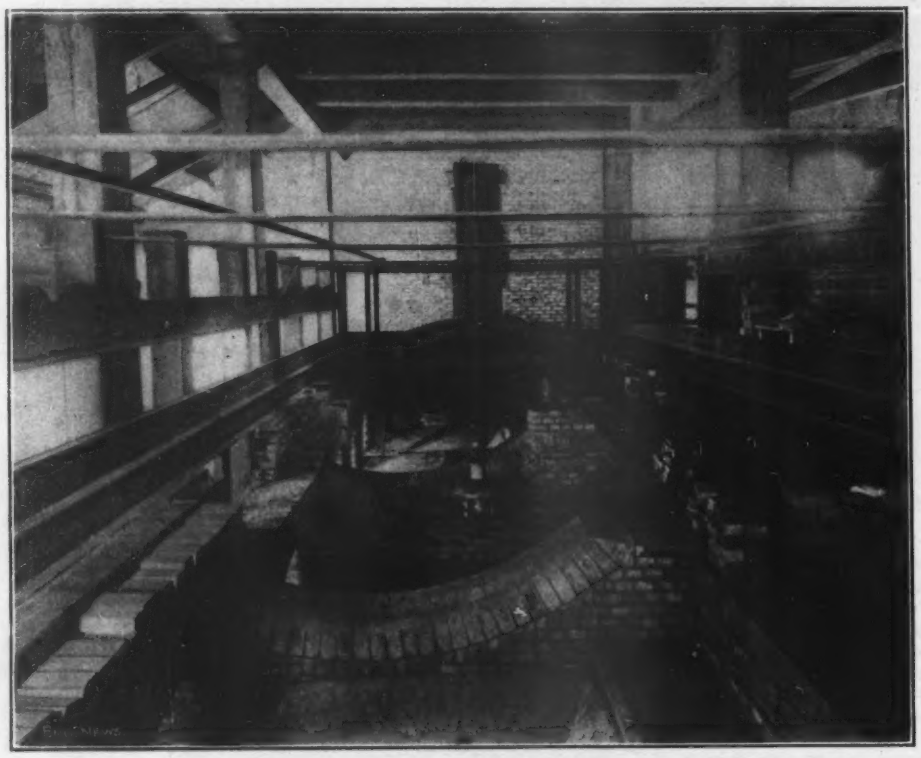


FIG. 7. PORTION OF MILWAUKEE REFUSE INCINERATOR UNDER CONSTRUCTION.

The labor used on the furnaces was not skilled in this kind of work. The firemen had about one month's experience on the furnaces before the tests were started, and were workmen without previous experience in high-temperature firing. The man shoveling on the feeding and mixing room floor was an ordinary laborer selected from a dozen or more working about the plant. During the tests to determine the cost of incineration, in accordance with the requirements of the specifications, one man charged the charging chutes on the feeding and mixing room floor and three men operated the furnaces below. These men operated the furnaces during the whole period of the test on average annual refuse. During the clinkering, one of the three men on the furnace worked in the basement handling the clinker car, and when full pushed the car to a point just outside the building, as required. The evaporation for determining the steam credit was based on measurements taken May 26. The results of the tests are given in Table I., showing the summary of the official tests of the Milwaukee refuse incinerator. Fig. 6 is a reproduction of three representative CO_2 charts. No measurements were made of the quantity of clinker produced, because with two other units operating it was impossible to isolate and weigh the clinker from the unit under test.

Supplementing the data in Table I. with respect to the conditions and guarantees called for in the specifications, reference may be made to several of the principal features, as follows:

The capacity of the furnaces was guaranteed to be such that 60 lbs. of refuse would be burned per sq. ft. of grate area per hour. This rate was easily obtained and the indications are that in practice a rate in excess of this figure can be quite regularly obtained.

It was specified that the temperature in the combustion chamber should not drop below 1,250° F., and that an average temperature should be maintained of at least 1,500° F. This feature was entirely satisfactory.

These furnaces when working at their normal load were required to produce a residual that is thoroughly burned, hard and free from organic matter. Chemical analysis of representative samples of residual showed the percentage of volatile matter to be 0.06% in clinker; 1.7% in ashpit ash; and 0.74% in the grate ash.

The steam production, equal to 1.25 lbs. of steam generated from and at 212° F., for each pound of refuse of the annual average composition, easily met the guarantee and in some ways sets forth the most distinctive feature of the Milwaukee refuse incinerator. The production of 0.87 lbs. of steam per pound of refuse of the extreme summer composition well illustrates this feature of this plant, and is a result which appears most striking to those interested in this question.

No odors, obnoxious gases, smoke or dust escaped from the chimney or building. The combustion chamber serves successfully as a dust settling chamber.

No nuisance was created at this plant during ordinary operations. In the basement where the clinker is removed, at times there was more or less dust noticeable as the clinker dropped through the trap door into the cars standing below. This feature will undoubtedly show improvement as the plant continues in service and the operators become more familiar with its proper performance. Taken as a whole the incinerator was found to be strikingly free from anything that could be designated as a nuisance.

The flues, dust collectors, furnaces and combustion chambers are arranged in an accessible manner and so that dust and ashes may be removed without any unreasonable delay.

Table II. shows the computation of the cost of incineration in accordance with the requirements of the specifications.

This cost, as is true of all other records of the tests, is computed according to the prices and conditions clearly set forth in the specifications, a synopsis of which has already been published in the Engineering News for April 22, 1909. On account of the limitations set forth in the specifications, the actual cost of operation is not set forth by these figures.

Operation.

Experience during May and June, 1910, indicated that the total cost of operating the new plant will not exceed $4,700 per month during the summer, and that the average throughout the year will not exceed $4,400 per month, making a total yearly cost of operation and maintenance of the new plant of $52,800.

As this incinerator continues in service it will no doubt be operated more economically than at the outset, when it is necessary to train new men to new duties. With the annual cost of operation and maintenance as above estimated, it is found that the cost of operation and maintenance per ton of mixed refuse is about 57 cts., on the basis of operating the plant at its full rated capacity of 300 tons per day for each working day in the year. Whether or not this figure will be reached during the first year of operation, depends largely upon the actual quantity of refuse incinerated. Using the 1909 figures

TABLE I.—SUMMARY OF OFFICIAL TESTS OF MILWAUKEE REFUSE INCINERATOR, MAY AND JUNE, 1910.

Date	May 19 & 20	May 23 & 24 June 3	May 26 to June 1
Duration, hours	37	36 hr. 26 min.	37
Grade of refuse tested	Extreme summer	Extreme winter	Average annual
Refuse burned, total tons	123.62	126.87	126.81
Percentage of garbage	56.7	29.7	40.8
Percentage of ashes	30.6	59.7	41.0
Percentage of rubbish	5.9	6.8	4.8
Percentage of manure	6.8	3.8	13.4
Rate of burning, tons per 24 hrs.	80	84	86
Lbs. per sq. ft. of grate area per hr.	63	65	64
Number of fires clinkered	57	62	63
Average time per clinkering, minutes	7.8	9	7.3
Evaporation per lb. of refuse:			
Gross actual, pounds	.79	1.19	1.10
Equivalent from and at 212° F., lbs.	.96	1.45	1.34
Net useful from and at 212° F., lbs.	.87	1.36	1.25
Temp. feed water, deg. F.	52	49	49
Ave. steam pressure, lbs. per sq. in.	146	133	130
Carbon Dioxide:			
Average, per cent.	9.3	8.8	12.9
Maximum, per cent.	16.0	19.8	17.2
Minimum, per cent.	6.2	5.5	3.5
Temperature, degrees F.:			
Combustion chamber ave.	1,607	1,668	1,664
Combustion chamber min.	1,267	1,240	1,267
Combustion chamber max.	1,880	2,060	2,000
Chimney gases	581	597	515
Forced draft, leaving heater	398	358	351
Pressure of draft leaving heater, ins of water	4.2	4.9	4.6
Furnace units under test	No. 4	Nos. 1 & 2	No. 1

TABLE II.—TEST COST OF OPERATION OF MILWAUKEE REFUSE INCINERATOR; AVERAGE ANNUAL REFUSE.

Tons incinerated during test		126.81
Labor required:		
One feeder, 37 hrs., at 25 cts.	$9.25	
Three firemen, 37 hrs., at 25 cts.	27.75	
¼ engineer's time, 37 hrs., at 37½ cts.	3.47	
Total cost	$40.47	
Cost of labor per ton		31.9 cts.
Steam from and at 212° F. to operate fan engine and feed pump per ton		219 lbs.
Cost of steam used per ton, at 4 cts. per 100 lbs.		8.8 cts.
Total cost to incinerate one ton		40.7 cts.
Total steam generated from & at 212° F. per ton		2,680 lbs.
Value of steam per ton of refuse burned at 4 cts. per 100 lbs.		107.2 cts.
Net profit per ton of refuse burned		66.5 cts.

for the cost of operation and maintenance of the old plant, including the cost of transportation across the river, an expense now eliminated, the cost of operating the old plant for the disposal of garbage alone on a yearly basis amounts to $64,256. This figure makes no allowance for power used for crane service and lighting at the old plant, as this power was furnished from an adjoining sewage pumping station without charge, as shown in the records of the health department, already mentioned. Power for these services at the new plant is developed from the combustion of the refuse. Further, in the estimates of the old plant no charge was made for the tug for towing the garbage across the river, as that was furnished by the city fire department without charge.

Comparing the operation of the old and new plants it appears that there is a saving of at least $11,000 per year, which at 4% will pay the interest charges on an expenditure of $275,000—a sum sufficient, not only to pay for the cost of the new plant, but also to pay for the cost of the installation of a power plant to utilize the excess steam developed at the new plant.

The new plant will develop an excess supply of steam from the combustion of the refuse which will be of real value for operating sewage pumps, lights or other municipal works. The value of the steam depends upon its use and no estimate has been included, although it is one of the chief credits of the new plant. Assuming that, of the four units at the new plant, one is held as a reserve and one is used for operating the plant itself, there remain 400 boiler HP. available for use elsewhere. This will operate a 500-KW. generator. Assuming the value of power to be one cent per KW. per hour, this represents a value for the excess steam of about $3,500 per month, or $42,000 per year.

In setting forth the merits and advantages of the new incinerator at Milwaukee, it is necessary to recognize the sanitary advantages of disposing of the rubbish by incineration; particularly with respect to such things as mattresses and other materials subject to infection. As cities increase in size it becomes more and more difficult to find accessible dumping grounds for the disposal of ashes and rubbish. The ability to dispose of ashes and rubbish in a modern incinerating plant without any difficulties as to nuisances from odors, smoke or dust is an item of much financial importance. It means that it is quite feasible with the proper location of a series of incinerating plants to reduce considerably the haul for the teams making the collections as compared with hauls necessary to suitable dumping places. Milwaukee, as well as many other cities, offers opportunities for effecting a saving in collecting rubbish and ashes to such an extent that the saving will more than pay the interest on the cost of the installation of modern incinerating plants at points where they can be located and utilized to best advantage.

These figures and comparisons are not given as a detailed study for the future development of refuse disposal in Milwaukee, but simply to indicate the inherent value of a modern incinerating plant along economical as well as hygienic lines.

Professional Conduct of Engineers in England.

By W. V. BALL.*

After considerable delay and prolonged agitation, the various faculties of engineers in England have adopted something in the nature of a written code of professional honor. Until quite recently every member of the great engineering profession has been a law unto himself. So long as he kept without the reach of the law, there was no tribunal to exercise any control over him.

In this respect it is to be observed that the profession of engineering is rather different to the other professions which hold sway in England. An English doctor is subject to the jurisdiction of a council which has power to prevent him practising if he is guilty of unseemly conduct. Lawyers, too, can be deprived if they are guilty of improper practices. But the engineers have hitherto had no system whereby the actions of those who call themselves engineers may be controlled.

An attempt is being made, however, to put this right. The Institution of Civil Engineers has recently passed certain disciplinary by-laws which are to be applicable to members of all classes. The same by-laws are to be adopted *in toto* by the Institution of Electrical Engineers; so that, in a very short time, most of those who are really entitled to call themselves "Engineers" in England will be subject to this new jurisdiction.

The text of these by-laws is as follows:

Every member of the Institution shall observe and be bound by the following regulations:

(1) He shall act in all professional matters strictly in a fiduciary manner with regard to any clients whom he may advise, and his charges to such clients shall constitute his only remuneration in connection with such work, except as provided by Clause 4.

(2) He shall not accept any trade commissions, discounts, allowances or any indirect profit in connection with any work which he is engaged to design or to superintend or with any professional business which may be entrusted to him.

(3) He shall not, while acting in a professional capacity be at the same time, without disclosing the fact in writing to his clients, a director or member of, or a shareholder in, or act as agent for, any contracting or manufacturing company or firm or business with which He may have occasion to deal on behalf of his clients, or have any financial interest in such a business.

(4) He shall not receive directly or indirectly, any royalty, gratuity, or commission on any patented or protected article or process used on work which he is carrying out for his clients, unless and until the receipt of such royalty, gratuity or commission has been authorized in writing by those clients.

(5) He shall not improperly solicit professional work either directly or by an agent, nor shall he pay, by commission or otherwise, any person who may introduce clients to him.

(6) He shall not be the medium of payments made on his clients' behalf to any contractor or business firm (unless specially so requested by his clients), but shall only issue certificates or recommendations for payment by his clients.

Any alleged breach of these regulations or any alleged professional misconduct by a corporate member which may be brought before the Council, properly vouched for and supported by sufficient evidence, shall be investigated, and if proved shall be dealt with by the Council either by expulsion of the offender from the Institution or in such manner as the Council may think fit.

The acute mind will observe a great difficulty in the application of these regulations. How are they to be enforced? Suppose a member of the Institution of Civil Engineers is guilty of a breach of one of these rules, he may cease to be a member of the institution; but there is no power to prevent him practising as an engineer. Nor have any of the institutions the right to prevent any person using the high sounding title "Consulting Engineer." That means more to the "man in the street" than the mysterious letters "M. I. C. E." which members of the engineering profession in England are wont to put after their names.

At the same time it is hoped that although there is no legal means of putting them into force, these regulations will have a moral effect which will be a great source of strength to the engineering profession in England.

*3 Brick Court Temple, London, E. C.

AN APPROPRIATION OF $150,000 for gaging streams and making various studies of water-supply and water resources will be available for the U. S. Geological Survey for use during the fiscal year 1910-11. A cessation of appropriations for this work was threatened several years ago, and for one year, if we remember rightly, the appropriation was only $50,000.

Failure of Concrete Piles Under Ocean Pier at Long Beach, Cal.

By L. A. WATERBURY.*

The accompanying view shows the break in the pleasure pier at Long Beach, Cal., which occurred upon July 4, 1910. The pier was built in 1904 at a cost of approximately $100,000. It is 1,800 ft. in length and 40 ft. in width, except the portion at the outer end which is wide enough to provide for the sun parlor and to provide landing space for pleasure craft. There are two decks, the upper one being used for a walk, while the lower deck accommodates a driveway and two sidewalks. The original supports for the pier consist of concrete piers or piles, 4 ft. in diameter, spaced 16 ft. 8 ins. apart longitudinally. Each of these piles was made by driving three wooden piles into clay which underlies the sand, placing a wooden caisson around the piles extending into the sand, and then filling the caisson with concrete deposited through the water. The concrete does not appear to have been very good, and as soon as the teredoes had destroyed the temporary wooden caisson, the supposedly permanent concrete began to disintegrate. Before the break occurred many of the concrete piles were entirely disintegrated near the water surface, the upper portion being held from above instead of acting as a support. As this destruction of the concrete has been going on for the past few years, the pier has been reinforced with wooden piling, which were placed wherever the additional support was needed. However, the pier has been gradually getting into such shape that such repairs were insufficient, and during the present year the city of Long Beach voted a bond issue of $75,000 to repair or rebuild the pier. These bonds have not yet been sold and it may be some time before this money will be available for use.

PIER AT LONG BEACH, CAL., SHOWING BREAK WHERE CONCRETE PILES HAVE BEEN WASHED AWAY.

At the time at which the break occurred the tide was at a very high stage and the breakers were unusually high for the height of the tide. For two days previous to July 4, the waves had been pounding the pier with considerable violence. Upon July 3 the pier was closed to traffic and remained closed until after the accident, so that no one was injured. At the time of the high tide of July 3, the waves practically completed the removal of all the underpinning at the place of the break, so that during the forenoon of July 4 the superstructure spanned the gap, being supported by the portions on either side. Upon the afternoon of the 4th, when the high waves began to roll inshore, more of the loose timbers were torn away and finally, between 4 and 5 p. m., when the waves had reached such a height that they were in contact with the lower deck, approximately 50 ft. of the superstructure was torn out, leaving the pier in the condition shown. The position of the break is very nearly at the point at which the waves break as they roll inshore.

*Professor of Civil Engineering, University of Arizona, Tucson, Ariz.

The Elementary Theory of the Gyroscope in the Brennan Monorail Car.

By EDWARD V. HUNTINGTON.*

The object of this article is: (1) to present a clear and compact statement of the elementary principles of the gyroscope, while carrying the theory only just so far as is necessary for an understanding of the action of the Brennan monorail car; (2) to give a demonstration of these principles based directly on the fundamental theorem of the dynamics of a particle, and therefore not presupposing any knowledge of the dynamics of a rigid body in three dimensions; and (3) to derive new formulas for the efficiency of the Brennan apparatus, which might well be useful, as a first approximation, in the actual design of the car. These formulas (see Theorems 4 and 5) are believed to be much more nearly correct than any hitherto published.

Fig. 1. Perspective Sketch of a Laboratory Gyroscope.

It is hoped that the article may be serviceable to teachers of undergraduate courses in mechanics, since it brings some of the most important parts of the gyroscope within the reach of anyone who has had a first course in the calculus.

The Geometry of the Problem.

The gyroscope, in its simplest form, is essentially a rapidly rotating wheel, so mounted that its center remains fixed in space, while its axle is free to point in any direction (see Fig. 1).

A glance at Fig. 2 will show that the position of such a body is wholly determined when the following three quantities are known:

(1) The "latitude" of the end of the axle, λ; (2) the "longitude" of the end of the axle, ψ; and (3) the "angle of rotation" (that is, the angle which a radius fixed in the wheel makes with the line of intersection of the plane of the wheel with the plane of the equator), ϕ.

A motion of the end of the axle up or down along a meridian, is called nutation, or nodding. A motion of the end of the axle along or parallel to the equator is called precession. The rotation of the wheel is called spinning.†

For the purposes of this article, the motion of nutation need not be considered, and the motion of precession will be confined to precession along the equator.

For brevity, we shall use accents to denote differentiation with regard to time, thus:

$$\frac{d\psi}{dt} = \psi', \quad \frac{d\psi'}{dt} = \psi'', \text{ etc.}$$

Steady Precession.

The first problem is the following: Suppose the wheel is spinning with angular velocity ϕ', while at the same time the end of the axle is "precessing" along the equator with a constant angular velocity ψ'. What external forces must be acting on the gyroscope to account for this motion?

The solution of this problem is contained in the following theorem, the proof of which will be given at the end of this article:

THEOREM 1.—If the gyroscope is spinning with constant angular velocity ϕ', while at the same time the end of the axle is precessing along the equator with constant angular velocity ψ' (both measured in radians per second), then the only external force necessary to maintain this motion is a constant force p acting downward at the end of the axle (with, of course, an equal reaction upward at the point of support). The magnitude of p is given by

$$p\,a = \frac{w}{g} r^2 \phi' \psi',$$

where a = the lever-arm of the force p, that is, the length of the axle from the center of the disk to the point of application of the force, w = the weight of the wheel, and r = the radius of gyration of the wheel about its axle.*

To apply this theorem, for example: Suppose w = 3,200 lbs., r = 1.414 ft., velocity of spinning = 3,000 r. p. m., precessional velocity = 3 r. p. m. Then $\phi' = 100\,\pi$ radians per second, $\psi' = 0.1\,\pi$ radians per second, and the moment of the force p is $pa = 2{,}000\,\pi^2 = 20{,}000$ lb.-ft. If the lever-arm $a = 1$ ft., then $p = 20{,}000$ lbs.; if $a = 2$ ft. then $p = 10{,}000$ lbs., etc. Thus a very large force is required to maintain even a very slow precessional motion.

The characteristic feature of this theorem is the fact that *the precessional motion of the end of the axle is at right angles to the applied force.*

In order to determine the direction (right or left) of the precession corresponding to the given force p, the most convenient rule is the following, which as far as I know has not heretofore been published: *If the applied force be thought of as due to the pressure of a shelf against the revolving axle, the axle will precess along the shelf in the direction in which it would naturally roll if the shelf were rough.*

It is interesting to notice, in passing, that the force p in the case we are considering does no work, since the point of application of the force does not move in the direction of the force. The kinetic energy of the gyroscope therefore remains constant, and the motion is analogous to the motion of a body sliding with constant velocity along a perfectly smooth table—no work being done by any external forces.

The theorem of this section, with the rule for the direction of precession just given, is sufficient to explain a large number of the interesting phenomena presented by the action of gyroscopic forces.

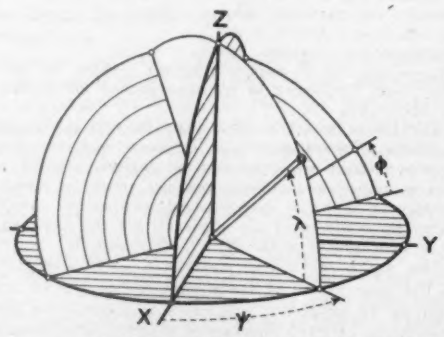


Fig. 2. Gyroscope Diagram, Showing Position Angles.

Accelerated Precession.

The second problem that we shall consider is that of accelerated precessional motion. Suppose the axle is precessing along the equator with a variable velocity, what are the external forces which must be acting to produce this motion? The facts in this case are expressed in the following theorem, the proof of which will be given later.

THEOREM 2.—If the gyroscope is spinning with constant angular velocity ϕ', while at the same time the end of the axle is precessing along the equator with an angular acceleration ψ'' $(= d\psi'/dt)$, then the external forces required at any instant to account for this motion are the following:

(1) A constraining force p acting downward at the end of the axle (with an equal reaction acting upward at the point of support), the magnitude of p being given by

$$p\,a = \frac{w}{g} r^2 \phi' \psi',$$

as in the preceding theorem; and (2) an accelerating force q acting along the equator (with an equal and opposite reaction at the point of support), the magnitude of q being given by

$$q\,b = \frac{w}{g} \frac{r^2}{2} \psi''$$

Here a, b, are the lever-arms of the forces p, q, respectively; r = radius of gyration of the wheel about its axle.

In this theorem, the force q is the force which directly accelerates the precession of the end of the axle, while the force p represents the pressure against the guides by which the axle is constrained to move along the equator.

For example, if w = 3,200 lbs., r = 1.414 ft., and velocity of spinning = 3,000 r. p. m., then a force q along the equator, of 50 lbs., with a lever arm of 2 ft., acting for ½ sec., will produce a precessional velocity of ½ rad./sec.; at the end of this time the pressure against the guides, assuming again a lever-arm of 2 ft., will have risen to nearly 16,000 lbs. The angular displacement of the end of the axle along the equator during this half-second will be ⅛ radian, or a little over 6°. Thus a comparatively small force q will produce a very large pressure p against the guides.

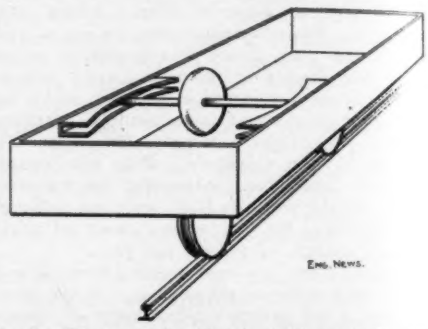


Fig. 3. Diagrammatic Sketch of Monorail Car With Gyroscope Arranged to Precess in the Plane of the Car Floor.

It should be noticed that the force q required to produce a given acceleration of the axle along the equator is entirely independent of the rate of spinning.* In other words, if the axle is constrained to slide in a smooth slot along the equator, then a force q acting along the equator will produce exactly the same motion of the axle along the equator whether the wheel is spinning or not; on the other hand, the lateral pressure, p, against the guides is directly proportional to the velocity of spinning. It is this latter fact which is utilized in the application of the gyroscope to the monorail car, as explained in the next paragraph.

Application to the Monorail Car.

The Brennan monorail car is a car running on a single rail, and balanced by means of a gyroscope contained in the car.† The apparatus in its simplest form may be described as follows: The gyroscope is mounted in gimbal rings, and its center of gravity is fixed in the central longitudinal plane of the car. The axle of the gyroscope stands normally in the thwartwise position—that is, horizontally when the car is on even keel, and across the car—and the end of the axle is free to move only in a longitudinal arc along a slot formed by two shelves attached

*Assistant Professor of Mathematics in Harvard University, Cambridge, Mass.

†As an aid to the memory, we note that precession and psi (ψ) have the same initial letter.

*If all the weight is concentrated at the rim, $r = R$, the radius of the wheel; if the wheel is a homogeneous solid disk $r^2 = R^2/2$.

*The remark made by Mr. Crabtree, in his new book on "Spinning Tops and Gyroscopic Motion," Sec. 52, to the effect that this motion is caused directly by p and not by q, and that it must be computed "according to the laws of precession," is decidedly misleading.

†In the actual car there are two gyroscopes, revolving in opposite directions; but this and other technical details will not be considered in this article.

to the inside of the wall of the car. Some device is provided by which the end of the axle may be forcibly pulled forward or backward through a certain angle along this slot (which is the "equator" of our theorems), by a force q which may be varied at will.

The balancing action of the gyroscope is then as follows: Suppose a wind pressure, or other external force, with a moment PA about the rail, tends to upset the car; the instant the car begins to tilt, an automatic device puts the force q into action; the force q gives the end of the axle a corresponding velocity, ψ', along the slot, and this velocity ψ' (by theorem 2) creates an upward pressure p against the shelf whose moment is $pa = (w/g)\, r^2\, \phi'\, \psi'$. Now by making q, and hence ψ', sufficiently large, this moment pa may be made larger than the moment of the wind-pressure PA, so that the car is actually forced over into the wind. The force q is then so regulated that the car is brought into what may be called the safe position, that is, the position in which the moment of the wind-pressure is exactly balanced by the moment of the force of gravity (see Fig. 4). Once brought into this position, the car runs along in lateral equilibrium, without further action of the gyroscope, until the next change in the wind.

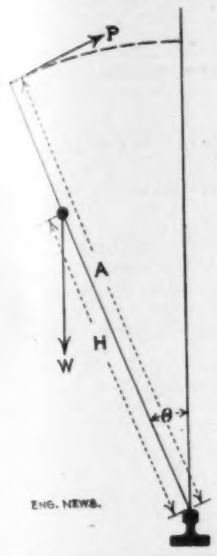


Fig. 4. Diagram Illustrating Position of Balance of Overturning Forces.

From Fig. 4, the "safe angle" Θ is given by $PA = WH \sin \Theta$, where PA is the moment of the external force about the rail, W the weight of the car, and H the height of its center of gravity above the rail. Now the comfort of the passengers demands that the angle Θ be not greater than a fixed amount, say 20°; hence the maximum value of the upsetting moment which the car can withstand does not depend on the power of the gyroscope, but is determined directly by WH. Within the limits thus set, the stability of the car depends, of course, on the weight and speed of rotation of the gyroscope.

It will thus be seen that the activity of the gyroscope is called into play only when changes occur in the external forces which act on the car, such as the forces due to wind-pressure, shifting of cargo, etc.; the function of the gyroscope being merely to tilt the car into a position in which these external forces balance themselves. An important part of the mechanism is a device, not here described, by which, after each period of activity, the end of the axle is brought back into the "ready position" at the middle point of the shelf.

Efficiency of the Brennan Apparatus.

It is evident from the preceding description that the righting effect of the gyroscope rapidly diminishes as the axle precesses along the shelf, and would become zero if the axle became parallel to the rail. In practice it is undesirable to use a shelf more than 10° or 15° long on each side of the normal position. The problem that presents itself at once is this: How heavy must the gyroscope be, and how rapidly must it rotate, in order that it may be possible to force the car over into the safe position before the axle has run off the end of the shelf?

Several attempts to solve this problem have been published, notably one by Prof. John Perry, in "Nature" (London), March 12, 1908, but none of them give any definite formulas that would be of much assistance in designing the car. The solution contained in the following theorem, while necessarily only approximate, is believed to indicate the essential conditions of the problem more correctly than any hitherto given.

THEOREM 3.—Let W = the weight of the car, K = the radius of gyration of the car about the rail, and H = the height of the center of gravity of the car above the rail. Let w = the weight of the gyroscope and r = the radius of gyration of the gyroscope about its axle. Let Θ = the safe angle to which the car may tilt, and Ψ = the angular length of the half shelf, that is, the angle subtended at the center of the gyroscope by half the length of the shelf. Then the necessary angular velocity of the gyroscope is

$$\phi' = \sqrt{\frac{H}{K^2}} \left[\frac{W K^2}{w r^2} \frac{\Theta}{\Psi} \sqrt{g} \right], \qquad (a)$$

or, if we write $K^2 = K_0^2 + H^2$, where K_0 = the radius of gyration of the car about an axis through its center of gravity and parallel to the rail.

$$\phi' = \sqrt{H}\ \sqrt{K_0^2 + H^2} \left[\frac{W}{w r^2} \frac{\Theta}{\Psi} \sqrt{g} \right]. \qquad (b)$$

For example, if $W = 64{,}000$ lbs. (which is about the weight of a heavy Pullman car), $w = 3{,}200$ lbs. (which is 5% of W), $H = 2$ ft., $K = 3$ ft., and $r = 1.414$ ft., and if we take $\Theta = \Psi = 15°$, then the required speed of the gyroscope is $\phi' = 240$ radians per second, or about 2,300 r. p. m.

In the light of this theorem, let us now consider the comparative speeds required for two cars of exactly similar shape, but of different sizes. Equation (a) is especially adapted for the discussion of this question. If all the linear dimensions of the car are multiplied by n, all the weights will be multiplied by n^3, and the factor in square brackets in the expression for ϕ' will be unchanged; the other factor $\sqrt{H/K^2}$, however, will be multiplied by $\sqrt{1/n}$. Hence we have:

> THEOREM 4.—If we multiply all the linear dimensions of the car, including the gyroscope, by n, we may divide the speed of the gyroscope by $\sqrt{n}$ and still have the same efficiency.

It thus appears that in case of the Brennan device, the apparatus is actually more efficient in a large model than in a small one.

The statement in theorem 4 agrees very well with the results of Mr. Brennan's own experiments; in his 8-ft. model, the speed of the gyroscopes was 7,000 r. p. m., while in his 40-ft. model ($40 = 8 \times 5$) the speed is reduced to 3,000 r. p. m. ($3{,}000 = 7{,}000 \div \sqrt{5}$, nearly). It is undoubtedly a better approximation to the truth that the statement made by Professor Worthington (The London "Times" Engineering Supplement, June 5, 1907), and repeated by Mr. Crabtree in his new book on "Spinning Tops and Gyroscopic Motion" (page 78), to the effect that if the linear dimensions are multiplied by n, the speed of the gyroscope may be divided by n (instead of by $\sqrt{n}$). This latter rule would not be a safe one to follow in practice; for example, in Mr. Brennan's 40-ft. model it would call for a speed of only 1,400 r. p. m., instead of the 3,000 r. p. m. properly required.

In order to compare our result with the result obtained by Professor Perry, let us suppose, with him, that the speed of the gyroscope is constant; and let all the linear dimensions of the car be multiplied by N, while all the linear dimensions of the gyroscope are multiplied by n. Then W will be multiplied by N^3 and w by n^3. Substituting in equation (a), and assuming that the angles Θ and Ψ are unchanged, we readily find that $n = N^{9/10}$. That is, assuming constant speed of rotation, the ratio of increase of the size of the gyroscope need not be so great as the ratio of increase of the size of the car. This result agrees closely with that obtained by Professor Perry, his exponent being 7/8, or 0.875, instead of our 0.9. Professor Perry's article, however, does not contain any formula analogous to our equations in Theorem 3.

Proportions of the Car.

Finally, let us consider the question of the best shape for a car of given weight, containing a gyroscope of given weight and size.

Turning to equation (b) of Theorem 3, we see that, under the conditions considered, the square bracket in the expression is constant, so that ϕ' is proportional to $\sqrt{H}\ \sqrt{K_0^2 + H^2}$. Regarding ϕ' as a function of the two independent variables K_0 and H, an easy differentiation shows that

$$\frac{d\phi'}{\phi'} = A \frac{dH}{H} + B \frac{dK_0}{K_0},$$

where A and B are quantities proportional to $K_0^2 + 3H^2$ and $2K_0^2$. This equation shows the percentage change produced in ϕ', under the given conditions, by given percentage changes in H and K_0. Hence:

> THEOREM 5.—For a car of given weight, with a gyroscope of given weight and size, the speed of rotation, ϕ', required to balance the car is proportional to $\sqrt{H}\ \sqrt{K_0^2 + H^2}$, where K_0 = the radius of gyration of the car about an axis through its center of gravity parallel to the rail, and H = the height of the center of gravity above the rail. Hence both K_0 and H should be made as small as practical considerations will permit; but if $K_0 > H\sqrt{3}$, a given percentage decrease in K_0 will have more effect on ϕ' than an equal percentage decrease in H, while if $K_0 < H\sqrt{3}$, a decrease in H will have more effect than a decrease in K_0; in a certain sense, therefore, we may say that, under the given conditions, the best shape for the car is attained when $K_0 = H\sqrt{3}$.

The relation $K_0 = H\sqrt{3}$ means, of course, that the car should be comparatively low and wide; and this is the case in both models constructed by Mr. Brennan.

Proofs of Theorems.

PROOF OF THEOREM 1.—The proof of Theorem 1 here given is based directly on the following fundamental law for the motion of a single particle under the action of any forces. If F = the sum of the components of the forces in any fixed direction, and A = the resultant acceleration in that direction, then

$$\frac{F}{W} = \frac{A}{g} \text{ or } F = \frac{W}{g} \frac{dv}{dt},$$

where W = the weight of the particle, and g = the acceleration of gravity.

To fix our ideas, we suppose for the moment that the mass of the wheel is concentrated at four points consecutively 90° apart around the

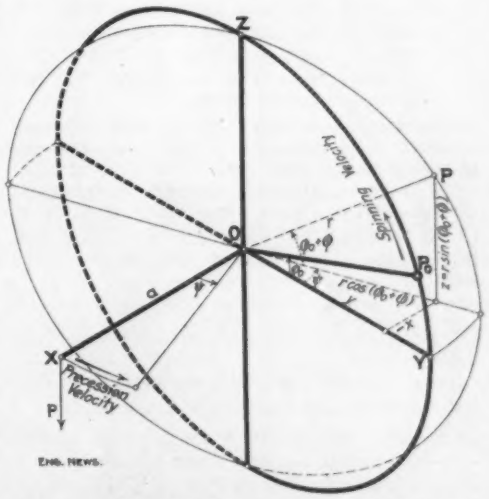


Fig. 5. Skeleton Sketch of Precessing Gyroscope Wheel, For Calculating Tilting Moment.

wheel, P_1, P_2, P_3, P_4; and let P_0, Fig. 5, indicate any one of these four points. Having chosen a set of fixed axes, OX, OY, OZ, as in Fig. 5, we suppose that at any given time t_0 the body has the position shown in heavy lines in Fig. 5, the axle coinciding with OX, and the radius OP_0 making an angle ϕ_0 with OY. At any later time $t_0 + t$ the body will occupy the position shown in lighter lines in the figure, the wheel having spun through an angle ϕ and the axle having precessed along the equator through an angle ψ, so that the point P_0 has now reached the position P.

We now proceed to find the acceleration of the point P at the instant t_0.

An inspection of Fig. 5 shows that the coordinates of P, at any time $t_0 + t$, are

$$\begin{aligned} x &= -r\cos(\phi_0+\phi)\sin\psi, \\ y &= r\cos(\phi_0+\phi)\cos\psi, \\ z &= r\sin(\phi_0+\phi). \end{aligned} \tag{1}$$

Differentiating with respect to the time t, we have for the components of the velocity of P:

$$\begin{aligned} x' &= -r\psi'\cos(\phi_0+\phi)\cos\psi \\ &\quad + r\phi'\sin(\phi_0+\phi)\sin\psi, \\ y' &= -r\psi'\cos(\phi_0+\phi)\sin\psi \\ &\quad - r\phi'\sin(\phi_0+\phi)\cos\psi, \\ z' &= r\phi'\cos(\phi_0+\phi). \end{aligned} \tag{2}$$

Differentiating again with respect to t, and remembering that ϕ' and ψ' are constants, we find the acceleration-components of P at the time $t_0 + t$, and, by putting $\phi = 0$ and $\psi = 0$ in the expressions thus found, we have the acceleration-components of P at the original time t_0:

$$\begin{aligned} x'' &= 2r\phi'\psi'\sin\phi_0, \\ y'' &= -r(\phi'^2+\psi'^2)\cos\phi_0, \\ z'' &= -r\phi'^2\sin\phi_0. \end{aligned} \tag{3}$$

To account for these accelerations, the particle must be acted on by three forces, $(w/4g)\,x''$, $(w/4g)\,y''$, $(w/4g)\,z''$, parallel to OX, OY and OZ,

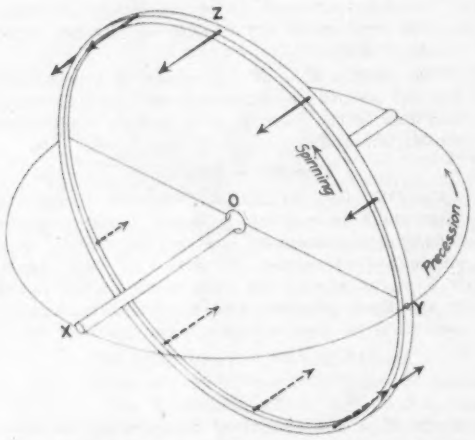


Fig. 6. Distribution of X-Forces During Steady Precession, Showing Existence of Moment Around Axis of Tilting.

respectively. Here $w/4$ = the weight of each particle, and we will write for brevity, $w/4\,g = m$. Dropping the subscript $_0$, the three forces are:

$$\begin{aligned} f_x &= m\,x'' = 2\,m\,r\,\phi'\psi'\sin\phi, \\ f_y &= m\,y'' = -m\,r(\phi'^2+\psi'^2)\cos\phi, \\ f_z &= m\,z'' = -m\,r\,\phi'^2\sin\phi. \end{aligned} \tag{4}$$

The last two of these forces, parallel to OY and OZ, lie in the plane of the wheel; the first is parallel to the axle, OX.

Let us now consider the moments of these three forces about the axes. The coordinates of P_0 at the instant t_0 are (putting $\phi = 0$ and $\psi = 0$ in equation (1), and then dropping the subscript $_0$):

$$x = 0,\ y = r\cos\phi,\ z = r\sin\phi.$$

Therefore the moment of the Y-force about OX is

$$z\,m\,y'' = -m\,r^2(\phi'^2+\psi'^2)\sin\phi\cos\phi, \tag{5a}$$

and the moment of the Z-force about OX is

$$y\,m\,z'' = -m\,r^2\phi'^2\sin\phi\cos\phi, \tag{5b}$$

so that the total moment about OX is

$$z\,m\,y'' + y\,m\,z'' = -m\,r^2(2\,\phi'^2+\psi'^2)\sin\phi\cos\phi. \tag{6}$$

Further, the moment of the X-force about OZ is

$$y\,m\,x'' = 2\,m\,r^2\phi'\psi'\sin\phi\cos\phi, \tag{7}$$

and the moment of the X-force about OY is

$$z\,m\,x'' = 2\,m\,r^2\phi'\psi'\sin^2\phi. \tag{8}$$

These equations (4) to (8) give the forces acting on a typical particle P_0, and the moments of those forces about the axes, at the instant t_0. To obtain the forces and moments for each of the four particles P_1, P_2, P_3, P_4, we have merely to replace ϕ successively by $\phi_1 = \phi_0, \phi_2 = \phi_0 + 90°$, $\phi_3 = \phi_0 + 180°$, and $\phi_4 = \phi_0 + 270°$, in these equations, according to the following table:

	P_1	P_2	P_3	P_4
$\sin\phi$.....	$\sin\phi_0$	$\cos\phi_0$	$-\sin\phi_0$	$-\cos\phi_0$
$\cos\phi$.....	$\cos\phi_0$	$-\sin\phi_0$	$-\cos\phi_0$	$\sin\phi_0$

Making these substitutions, and adding the resulting equations, we have at once the following results: the sum of all the forces acting on the four particles is zero; the sum of the moments of the Y-forces and the Z-forces about the axle OX is zero; also, the sum of the moments of the X-forces about the vertical axis OZ is zero; but from equation (8), since $2\sin^2\phi_0 + 2\cos^2\phi_0 = 2$, the sum of the moments of the X-forces about the horizontal axis OY is

$$4\,m\,r^2\phi'\psi'.$$

Representing this moment about OY by pa, and replacing m by $w/4\,g$ where w = total weight of the four points, we have

$$pa = \frac{w}{g}\,r^2\phi'\psi'. \tag{9}$$

and thus the theorem is established for the special case which we have been considering, namely, the case in which the weight of the wheel is concentrated at four points.

To extend the theorem to the case of a wheel with the weight uniformly distributed around the rim, we have only to notice that the value of p given by (9) is independent of ϕ_0, that is, independent of the position of the set of four points; hence, since the solid rim may be thought of as made up of a number of such sets of four points, the theorem will hold true for a solid rim, if we interpret w as the total weight of the rim.

Fig. 6 shows from the first equation of (4) the forces parallel to OX. It is clear from the figure that they will have a turning moment about OY. Fig. 7 shows the forces that lie in the plane of the wheel, the components being taken along the tangent and normal instead of parallel to OY and OZ; the figure shows clearly how all these forces cancel each other out.

Finally, since a solid disk may be regarded as made up of concentric rims, a simple integration will show that the same theorem holds for a solid disk of weight w, if we interpret r as the radius of gyration of the disk.

PROOF OF THEOREM 2.—The proof of Theorem 2 is similar to that for Theorem 1, except that in differentiating equations (2) we must remember that ψ' is now a variable, so that the resulting expressions for the acceleration-components will involve ψ''. Proceeding as before, the equations corresponding to (4) will read:

$$\begin{aligned} f_x &= m\,x'' = 2\,m\,r\,\phi'\psi'\sin\phi - m\,r\,\psi''\cos\phi, \\ f_y &= m\,y'' = -m\,r(\phi'^2+\psi'^2)\cos\phi, \\ f_z &= m\,z'' = -m\,r\,\phi'^2\sin\phi. \end{aligned} \tag{10}$$

Here the last two equations, for the Y and Z-forces in the plane of the wheel, are the same as before, and the moments of these forces about the axle are zero.

The moment of the X-force about OZ is now

$$y\,m\,x'' = 2\,m\,r^2\phi'\psi'\sin\phi\cos\phi - m\,r^2\psi''\cos^2\phi,$$

and the moment about OY is

$$z\,m\,x'' = 2\,m\,r^2\phi'\psi'\sin^2\phi - m\,r^2\psi''\sin\phi\cos\phi.$$

Replacing ϕ in these equations by ϕ_1, ϕ_2, ϕ_3, ϕ_4, and adding, we see that the sum of the moments about OY is

$$4\,m\,r^2\phi'\psi' = -\frac{w}{g}\,r^2\phi'\psi'$$

as before, while the sum of the moments about OZ is

$$2\,m\,r^2\psi'' = -\frac{w}{g}\,\frac{r^2}{2}\,\psi''.$$

From these results the theorem follows at once.

PROOF OF THEOREM 3.—For the proof of this theorem we require the following well-known principle concerning the rotation of a rigid body about a fixed axis, namely, the sum of the moments of the external forces about that axis is equal to the angular acceleration times the moment of inertia about the axis of rotation, or

$$Fr = \frac{W}{g}\,K^2\,\frac{d\theta'}{dt},$$

where K = the radius of gyration of the body about the given axis and θ' is the angular velocity.

Turning to Fig. 4, and applying the principle of rotation, we have, for any angle θ (less or greater than the angle of safety Θ_1),

$$W\,H\sin\theta - P\,A = \frac{W}{g}\,K^2\,\theta''.$$

But $PA = WH\sin\Theta_1$ and $\sin\theta = \theta$, approximately. Hence, writing

$$n^2 = gH/K^2$$

we have

$$\theta'' = n^2\,\theta - n^2\,\Theta_1.$$

The solution of this differential equation, under the initial conditions $t = 0$, $\theta = 0$, $\theta' = \theta_0'$, is

$$\theta = \Theta_1 + \frac{\theta_0'}{n}\sinh(n\,t) - \Theta_1\cosh(n\,t),$$

as may be verified by substituting in the given equation. Hence,

$$\theta' = \theta_0'\cosh(nt) - \Theta_1\,n\sinh(nt).$$

These two equations give the position and the angular velocity of the car about the rail at any time t, supposing that it starts with a velocity θ_0' in the direction against the wind. Expressing the condition that $\theta' = 0$ at the instant when $\theta = \Theta_1$, we find

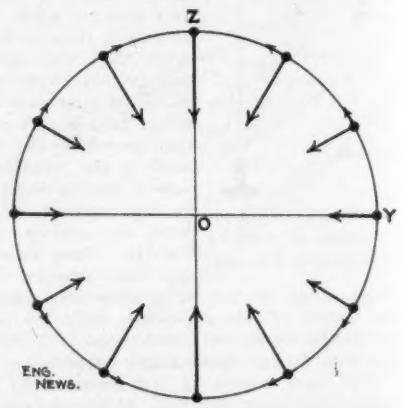


Fig. 7. Distribution of Forces in Plane of Gyroscope Wheel During Precession.
(Radial and Tangential Components of Y- and Z-forces.)

$$\tanh(nt) = \frac{\theta_0'}{n\,\Theta_1} = \frac{n\,\Theta_1}{\theta_0'},$$

whence, $\theta_0' = n\,\Theta_1$,

where $n^2 = g\,H/K^2$.

This gives the angular velocity with which the car must start against the wind if it is to come to rest at the angle of safety.

We now suppose that this initial angular velocity is imparted to the car by a sudden impulse exerted by the gyroscope. If pa is the moment of the pressure exerted by the axle against the shelf, we have, by the principle of rotation,

$$p\,a = \frac{W}{g}\,K^2\,\frac{d\,\theta'}{d\,t},$$

whence, integrating over the interval of time during which the force is acting,

$$\int_0^t p\,a\,dt = \frac{W}{g}\,K^2(\theta_0' - 0), \text{ where } \theta_0' = n\,\Theta_1.$$

But by Theorem 2, $p\,a = \frac{w}{g}\,r^2\phi'\psi'$,

whence, integrating over the same interval,

$$\int_0^t p\,a\,dt = \frac{w}{g}\,r^2\phi'(\Psi_1 - 0).$$

Equating the values of these two integrals, we have a relation between Θ_1, the angle of safety, and Ψ_1, the angle through which the axle has precessed along the shelf during the impulse; from this relation the equation (a) of Theorem 3 is readily obtained.

Hypochlorite Disinfection of the Water-Supply of Toronto, Ont.

By T. AIRD MURRAY,* M. Can. Soc. C. E.

The following information relating to the reduction of total bacteria and the total elimination of intestinal bacteria by the temporary use of hypochlorite as a disinfectant of the water-supply of Toronto, Ont., should prove of interest.

Toronto, on the advice of the writer, resolved in the latter end of March to apply small quantities of calcium hypochlorite to the city water-supply.

The months of February and March were accompanied by a high and increasing typhoid rate, while the water was stated by the city medical department to be very bad, and all users were recommended to boil the water.

The greater part of Toronto sewage is discharged untreated into the bay, which is divided from the lake by a long sand bar forming an island. At the east and west ends of the island there are channels cut allowing entrance to the bay. The water-supply is obtained not from the bay, but from a point in the lake south of the island.

Strong currents alternate from the east and west entrances between the bay and the lake depending on wind direction. Consequently much of the polluted bay water flows into the lake, proper and works its way around the island to the vicinity of the water intake.

In the winter time the whole of the bay is frozen over, oxidation of the bay water is reduced, and consequently a greater degree of pollution of the lake water makes itself evident. Especially is the increase in pollution made evident on the breaking up of the bay ice, which is used for several months as a highway between the island and mainland. It is also apparent that large quantities of raw sewage must be retained "in cold storage" in the ice during the winter months, only to be released in bulk in the spring of the year.

The intake pipe is carried out into the lake to a depth of 75 ft., and of late it has been found that a sand bank has formed around the base of the intake 25 ft. in height, reaching almost to the turned up intake influent, which is about 50 ft. below the lake surface.

Beyond the influence of wave action and contaminating influences of Toronto sewage, Lake Ontario presents a water of a very high purity standard. It is, in fact, both chemically and bacteriologically pure, with a hardness represented by only about 7°.

BACTERIAL REDUCTION EFFECTED BY TORONTO WATER DISINFECTING PLANT, APRIL 3 TO 23, 1910.

(Using .33 parts to 1,000,000 available chlorine added. Numbers indicate bacteria per c.c.)

Effect on Total Bacterial Contents.

April.	Raw water.	Disinfected.	Reduction—Number.	Reduction—Per cent.
3.....	1,680	450	1,230	73.2
6.....	710	140	570	80.2
7.....	810	380	430	53.0
8.....	280	180	100	35.6
9.....	4,120	980	3,140	76.2
10.....	1,425	380	1,045	73.3
11.....	290	60	230	79.3
13.....	3,310	70	3,240	97.9
14.....	150	40	110	73.3
15.....	2,670	960	1,710	64.0
16.....	1,210	50	1,160	95.9
17.....	460	170	290	63.0
18.....	9,270	1,890	7,380	79.6
20.....	3,520	1,420	2,100	59.6
22.....	280	100	180	64.3
23.....	1,890	80	1,810	90.4
Average.	2,005	458	1,545	77%

Effect on B. Coli.

	Samples.	B. Coli absent.	B. Coli present.
Raw water.....	16	9	7
Disinfected water.	16	16	0

Percentage positive tests for "B. Coli" in 1 c.c. of raw water for 16 tests, 44%.

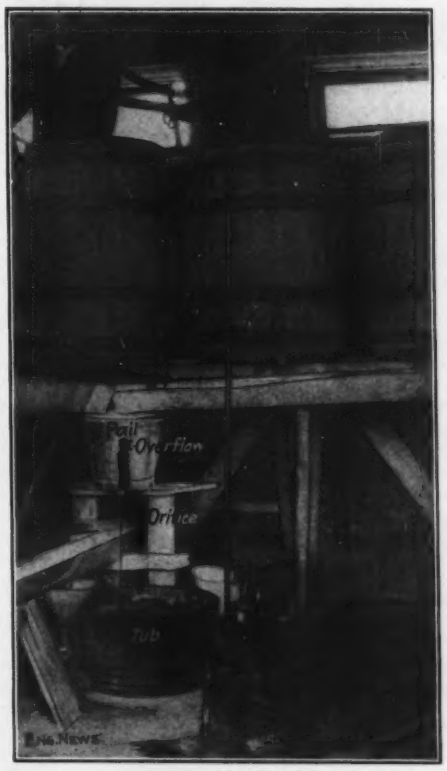
Percentage positive tests for "B. Coli" in 1 c.c. of disinfected water 0.%.

It is a well-known fact that storage of water tends to reduce the number of bacteria, and we have a good example of this in the lake. The line dividing the zone of turbidity from the blue, clear water is at times distinctly marked, and a sample of water may be taken at one side of a boat containing any number of bacteria below 100 per c. c., while on the other side within the yellow or turbid water a sample may show over 5,000 bacteria per c. c.

The dividing line between turbid and clear water is ever shifting, depending on strength and direction of winds, while there is practically no constant current in any one direction. The strongest currents are, however, from the east, owing to a greater stretch of water surface exposed in this direction to the full force of the wind. In fact, the island has been built up by the action of this current carrying sand from Scarboro Bluffs, about five miles to the east.

The table of the numbers of bacteria in the raw water show great variation, 150 per c. c. being the lowest count, while 9,270 is the highest. The variations are entirely due to wind and consequent increase or decrease in turbidity.

The almost daily samples which were taken both of the raw and disinfected water were for the purpose of determining the advisability of continuing the use of the disinfectant. The results have so far justified the continuation of the treatment.



Dosing Apparatus for Hypochlorite Disinfection, Water-Supply of Toronto, Ont.

The apparatus for applying the disinfectant is of a crude and temporary character. It consists, as the photograph shows, of ordinary barrels mounted on staging. The chloride of lime is mixed in the barrels by hand, and after the calcium hydrate has settled, the liquid flows into a receiving trough, and then into an ordinary metal pail with an overflow fixed to provide the constant head at the outlet orifice to measure the amount required at the rate of .33 parts per 1,000,000 of available chlorine.

The whole plant has not cost $100, while the cost of disinfection and operating amounts to 52 cts. per 1,000,000 gals. [or about 43.5 cts. per U. S. gal.—Ed.]. Thus 35,000,000 Imp. gals. of water are treated per day at a cost of $18.20, and this figure has of late been reduced somewhat.

An interesting feature of this temporary plant lies in the fact that we are treating an unfiltered water with a very small amount of chlorine, and yet good results are obtained. It is generally acknowledged that all methods of disinfection relying on nascent oxygen as the germicide provide efficiencies in proportion to the amount of chemical used, depending on the successful removal of suspended organic matter. With Lake Ontario water, even under conditions of turbidity, the organic suspended matter is low. The suspended matter for the most part consists of almost ultra microscopic sand particles which only settle out slowly by sedimentation, turbidity lasting for several days after a lake wind storm.

It is, therefore, apparent that we have a water which is peculiarly adapted to direct sterilization; although, of course, it is undoubted but that much higher germicidal efficiencies would be obtained if the water was first filtered, even with roughing filters. Apart from occasional turbidity, color is practically nil.

Since the introduction of the disinfectant, there has been a diminution of the typhoid rate equivalent to the reduction of bacteria. For instance, the typhoid rate for the two months following disinfection shows a reduction of 78% from the two months previous to disinfection, while the average bacterial reduction by disinfection has been 77%. How far this is due to coincidence it is impossible to say, as, apart from disinfection, it was to be expected that the typhoid rate would show a decrease with improved weather conditions.

At the present time Toronto has in hand the installation of an up-to-date slow sand filtration plant. This, however, will not be complete until some time in the fall of next year. Further, the prevention of the pollution of the bay is being undertaken by the construction of trunk intercepting sewers which will concentrate the sewage at one point about 2½ miles east of the intake pipe. In the meantime it is satisfactory to know that we have simple means at hand for reducing the total number of bacteria, and for the total elimination of intestinal bacteria.

It is interesting also to know that the small amount of chlorine added to the water can have no possible effect apart from its germicidal action, and even if the calcium hydrate were also dumped into the water it would only add 1 part per 1,000,000, whereas there are 20 parts of lime normally in the untreated water.

The small amount of hydrochloric acid formed by the combination with the chlorine with the hydrogen in the water does not even chemically amount to a trace, and diluted over 3,000,000 times loses all possible effect.

From a statement recently made by the Medical Health Officer of Toronto it is very probable that Toronto will add disinfection to the new sewage disposal plant, and that the settled sewage liquid will be so treated before discharging it into the lake.

*Consulting Sanitary Engineer, Continental Life Building, Toronto, Ont.

A STUDY OF EFFICIENCY AND ECONOMY IN THE transaction of the business of the United States was recently authorized by Congress. Under this authorization, the President is empowered to employ "accountants and experts from official and private life" to make a study of the business transactions of the various government departments "with a view of inaugurating new or changing old methods of transacting such public business so as to attain greater efficiency and economy therein." Recommendations are to be made to Congress as to what changes in law are necessary to carry improvements into effect in so far as improvements deemed advisable require further authorization. An appropriation of $100,000 has been made to carry on the study.

A WATER FILTRATION PLANT FOR MONTREAL, P. Q., is recommended in a report just submitted to the city authorities by Hering & Fuller, of New York City. After considering possible supplies from distant sources, and concluding that these would be not only expensive but would also require filtration, the engineers recommended a continuation of the use of the St. Lawrence River, with double filtration. Approval is also given to the proposal to enlarge the existing power canal and enlarge the water-power pumping plant, all at an estimated cost of $2,250,000. The estimated cost of the filtration plant is $1,445,500, exclusive of land, and the annual charges on the proposed plant are estimated at $130,000, including operation, maintenance, and capital charges. These cost figures are for a plant with a capacity of 50,000,000 Imp., or 60,000,000 U. S. gals. per day. Approval is given to plans already under construction for extending the river intake some 1,200 ft. or so from the shore and connecting it with the head of the present closed conduit.

Reconstruction of the Washington St. Tunnel Under the Chicago River.

The reconstruction of the street railway tunnel under the Chicago River at Washington St., Chicago, is a work of unusual character, presenting features of interest both in regard to the general proposition and to the special methods employed. The lines of the Chicago Railways Co. cross the river by three tunnels (in addition to several bridges), and in connection with the deepening of the river the War Department a few years ago called upon the city to remove or lower these tunnels, as forming obstructions to the channel. The traffic is too heavy to permit of the permanent abandonment of the tunnels, but after negotiations between the city authorities and the company a plan was adopted involving the reconstruction of the tunnels at a lower level during a period of temporary abandonment.

The plan was to build in each tunnel a new flat roof, at the level required for the lowered grade, supporting this in the sidewalls, and making it watertight. This being completed, the old arch roof could be broken down and the debris removed by dredging. The excavation and construction of the new tunnel could then be carried on at leisure beneath this roof by such methods as might be adopted later. This work was described and illustrated in our issues of Sept. 13, 1906, and March 7, 1907. It has been carried out successfully at the Van Buren St. and Washington St. tunnels, but at the La Salle St. tunnel the water broke in through the old work and in spite of various attempts it was found impossible to seal the leaks and prevent flooding. The plan was therefore abandoned in this last case, and the old roof was destroyed, leaving the construction of a new tunnel (independent of the old work) to be taken up at a later time.

The Van Buren St. tunnel is practically completed, the Washington St. tunnel is well advanced, and work has commenced upon the approaches for a new deep level tunnel at La Salle St. The present article deals with the Washington St. tunnel, and it may be noted that different methods of working have been employed in each of the three cases. The new roof of this tunnel was completed in 1908, and the old brick arch roof was removed by drilling and blasting, a drill-boat used in submarine work being employed for the purpose. At each end of the new roof, a bulkhead wall was built up to the roof of the old tunnel so as to prevent any water getting behind the new work.

The river tunnel is of practically rectangular section, with a flat roof, vertical walls and invert. The permanent approaches will be twin single-track tunnels extending from the river to a connection with the street-railway subway system on each side. The subways, however, will not be built for some years, and in the meantime connection must be made with the existing surface lines. This has necessitated special construction on part of the approaches. For the present, the approaches will be steep grades extending to the street surface, and this necessitates omitting the future permanent roof for the stretch of tunnel where the two grades diverge. This part of each approach, therefore, is built partly as an open cut with retaining walls and partly as a double-track tunnel of considerable (but varying) height, with the floor at the level of the permanent lower grade, and the roof at such an elevation as to clear cars on the upper temporary grade.

When the subway system is completed, the center wall and roof for the twin-tunnels will be built inside the double track section and the space above the new roof filled in. This arrangement is clearly shown by the profile, Fig. 1, and the several cross-sections. These are described more fully further on. The permanent approaches have grades of 3% on the east and 5.3% on the west side, separated by about 80 ft. of level track under the river. The temporary approaches have grades of 10% on the east and 9.5% on the west side. In the temporary open cut work, the retaining walls will be braced by transverse concrete struts below the level of the temporary grade. The floor and tracks will not be carried by these struts, however, but will be supported on timber trestling resting on the invert of the permanent work.

The total length of the work is about 1,550 ft., extending from Franklin St. to Clinton St. Beginning at Franklin St. (on the east side of the river), there is a twin-tunnel (under the temporary open incline approach) from the future subway connection for about 270 ft. (sections A and B in Fig. 1). This is shown on Fig. 2, and is followed by a single arch double-track tunnel (Fig. 3), 30 ft. wide, for about 295 ft. (sections C, D and E, Fig. 1). This has a height ranging from 40 ft. to 22 ft., but eventually will have a new roof at a lower level, as described above. Beyond this is the river tunnel of rectangular section, 25 ft. wide and 20 ft. 6 ins. high at the middle from the invert to the flat roof (section G) as shown in Fig. 4. The submarine portion is 152 ft. long, but the section is continued under each shore to a total length of 316 ft. Continuing westward, there is a twin-tunnel (section F) for 150 ft. followed by a single-arch double-track tunnel with high roof (section E) for 165 ft., extending to the west side of Canal St. Beyond this is 350 ft. of open incline for the temporary approach to the surface of Clinton St. Eventually the twin-tunnel section will be extended through the bottom of this cut and high tunnel to the connection with a subway under Clinton St., as described for the east side. The twin tunnels are 14 ft. wide and 20 ft. high, with vertical sides and center walls, inverts, and flat-arch roofs of reinforced concrete.

The work is under the direction of the Board of Supervising Engineers which has supervision of all the street railway reconstruction work, and which represents both the city and the railway companies. The general plans prepared by the Board provided for carrying out the work in the open, within cofferdams (obstructing half the width of the river at one time), and by a method of construction by which a complete section of the tunnel (including invert, walls and arch) could be completed without delay and as a continuous operation. The contractor, however, was permitted to submit alternative plans for approval. The contract was awarded to Geo. W. Jackson (Incorporated), of Chicago, and this firm proposed to do the work by tunneling on a new and ingenious plan, which is described below. The plan was approved and carried out with success.

Mr. Bion J. Arnold, M. Am. Soc. C. E, is President and Chief Engineer of the Board of Supervising Engineers, and Mr Geo. Weston, M. Am. Soc. C. E., is Assistant Chief Engineer. Mr. Wm. Artingstall is Division Engineer, in charge of the work at the three tunnels. Mr. L. Z. Murphy is Chief Engineer for the Chicago Railways Co. The work was under the general direction of Mr. Geo. W. Jackson, President and Chief Engineer of the contracting firm, with Mr. E. A. Clark as Assistant Engineer, and Mr. Fred. I. Fee, Division Engineer. The men in direct charge for the contractor were as follows: on the river section and the west approach as far as Canal St., Thomas McLane, Superintendent, and B. Rasmussen, Engineer; on the end of the west approach, John Casey, Superintendent, and R. M. Burkhalter, Engineer; on the east approach, Wm. Kennedy, Superintendent, and W. F. Smith, Engineer. The contract was let in 1909. By the end of April, 1910, the river section was practically completed, and work was well advanced on the approaches.

The River Tunnel.

The new roof built in the old Washington St. tunnel consists of 32-in. plate girders 51 ins. apart, carrying a deck of steel buckle plates. Concrete arches are formed between the girders, and a concrete roof covers the steel deck. This roof is supported upon the old masonry a little above the level of the original footings, as shown in Fig. 4. The problem was to drive a tunnel under this roof without causing any settlement or weakening, and without any liability of the river breaking in.

The plan devised by Mr. Jackson (as noted above), and patented by him, is shown clearly in Fig. 4. In the first place, there was driven on the

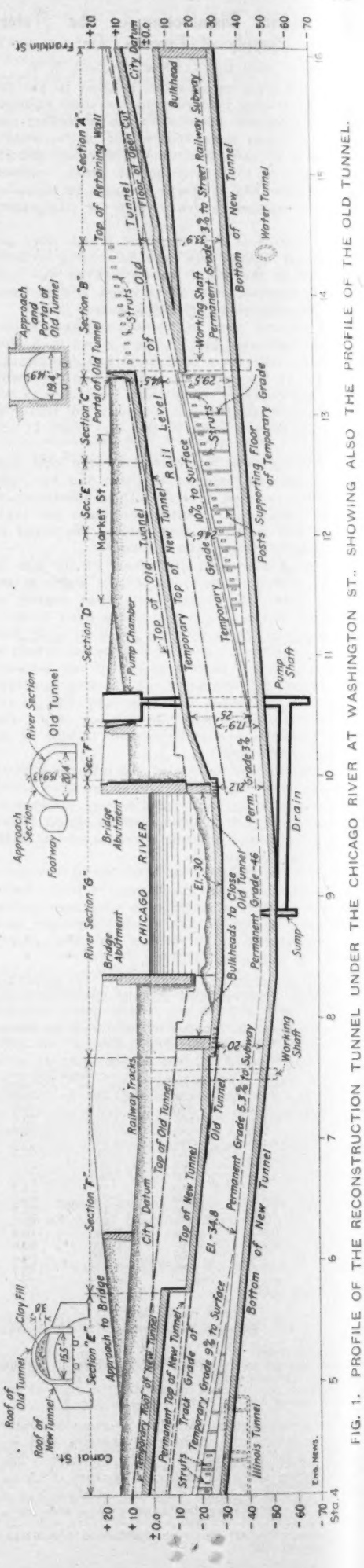


FIG. 1. PROFILE OF THE RECONSTRUCTION TUNNEL UNDER THE CHICAGO RIVER AT WASHINGTON ST., SHOWING ALSO THE PROFILE OF THE OLD TUNNEL.

line of each side wall a drift (A) of approximately rectangular section, the floor being at the level of the base of the wall. The completed drifts were then filled with concrete, to form the lower part of each wall. Similar drifts (B) were then driven above these, for the upper portions of the walls, the steel centering of these drifts serving as underpinning for the roof (previously built) until the concrete had been filled in the drifts and become hard. A modification of this plan was adopted for part of the work, as described later.

The general procedure being thus explained, we may turn to a more detailed description of the method of working, which will be understood by reference to the plan, Fig. 5. A concrete-lined working shaft, 7½ ft. diameter, was sunk about 100 ft. west of the river, and reaching to 70 ft. below the surface (60 ft. below datum), or below the bottom of the invert at this point, as shown in Fig. 1. At about 50 ft. below the surface a 25-ft. drift of horseshoe section, 6½ × 7 ft. (lined with concrete) was driven east on the center line of the tunnel, ending in an air lock 18 ft. long and of the same section. The drift was built with steel ribs and wooden lagging. Beyond the lock, two diverging drifts of the same size were driven on a down grade to the location of the tunnel walls, and from each of these was started the rectangular drift for the wall (A, Fig. 4). An electric cable hoist with 5 HP. motor handled the cars on the inclined forked drifts. An air pressure of about 10 lbs. was carried in the working drifts beyond the lock.

The bottom drifts were braced with steel frames 3 ft. apart, each consisting of two 5-in. channel posts with a transverse 4-in. I-beam at the top and at 6 ft. from the floor, while at the floor a 4 × 8-in. timber brace was put between the posts. Outside of the framing was the lagging of 3 × 8-in. plank, in lengths of 3 ft. to 6 ft. The drifts were 6½ ft. wide at the base and about 9 ft. high. In the top were formed benches to serve as a key for the upper section, and the bottom of the inner face was shaped to form a skewback for the future invert.

Each bottom drift was driven entirely across the river and to a point beyond the east bank. It was then filled with concrete, the gang working backward toward the shaft. The steel framing was left in place embedded in the concrete, but the timber braces at the bottom were removed as the work progressed. The outer lagging of course remained permanently in place, but the inner lagging was recovered subsequently in excavating the material between the drifts or walls). Reinforcing bars were placed in the bottom of the wall, at the skewback for the invert, and at the key for the upper section of the wall.

The concreting being finished, a short inclined drift was excavated inside the line of the face of the wall, to give access to the upper drift (B, Fig. 4) which was then driven over the top of the concrete-filled drift. The roof of the upper drift was supported by timbering and jacks in advance of the steel framing. This framing was much heavier than that of the bottom drifts as it formed the underpinning of the roof (previously built). Each frame consisted of two 9-in. I-beam posts, with 12 × 12-in. base plates, a tie rod at the bottom and a 12-in. channel at the top. These frames were 18½ ins. apart in the south drift and 24 ins. in the north drift. A floor of 6 × 8-in. timbers was laid in the drift. On the outer side was 6 × 8-in. lagging, left in place; the lagging on the inner side (recovered in excavating the tunnel proper) was of lighter material, laid against 2-in. fillers on the posts. The drifts were completed and then filled with concrete as described above. The steel was left in place, but the 6 × 8-in. floor was removed as the concrete filling advanced.

In the first part of the work for the upper part of the wall, a somewhat different method was employed. Owing to the uncertainty as to the condition and character of the material it was thought inadvisable to drive a continuous drift with underpinning for the roof, and the plan adopted was to drive a working drift just inside the line of the face of the wall, as shown in Figs. 5 and 7. This was 3 × 6 ft. in the clear, with 12 × 12-in. timbering and jack supports for the roof. As each advance of 6 ft. was completed, the drift was widened so as to form an excavation for the wall, and this was concreted. The drift was then advanced 6 ft., widened, and the side portion filled with concrete. Thus the wall was completed in 6-ft. lengths, so that there was no chance for a slide or movement. The material proved to be of such good quality, however, that a return was made to the through-drift method already described, the working drift being diverted to the position of the future wall, as shown on the plan, Fig. 5. This drift was then run the full length of the river section, the permanent steel frames being erected as underpinning for the roof. When this was completed, the work of concreting was begun at the far end, the gang working backward, and leaving the completed wall behind them.

The concrete for the wall was a 1:2:4 mixture, using sand and ¾-in. stone. It was dumped on the floor from cars and shoveled into place behind temporary transverse partitions to serve as forms. The concrete was made fairly wet, and special care was taken to have it well placed and tamped, so as to ensure a dense and homogeneous mass. No waterproofing course was laid

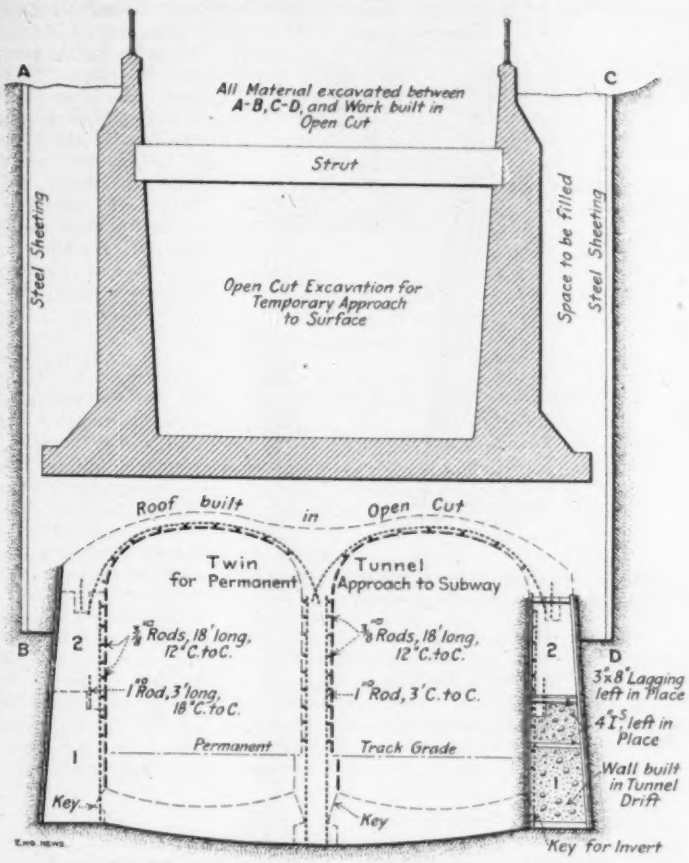


FIG. 2. CROSS SECTION OF OPEN APPROACH AND TWIN-TUNNEL AS BUILT IN OPEN CUT BETWEEN LINES OF STEEL SHEETING.

(The open approach between retaining walls is for the temporary grade, to connect with lines at the street surface. The twin-tunnel is for the permanent grade, to connect with the future street-railway subway.)

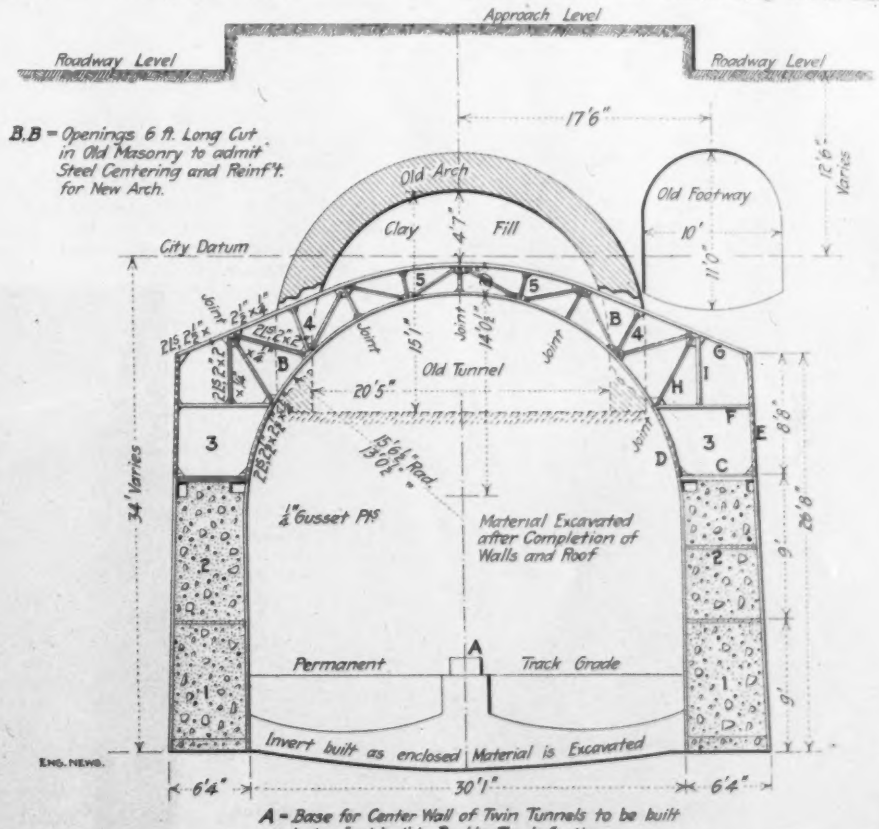


FIG. 3. CROSS SECTION OF DOUBLE-TRACK APPROACH TUNNEL, SHOWING THE METHOD OF BUILDING THE SIDE WALLS, AND THE METHOD OF PLACING THE ROOF TRUSSES FOR REINFORCEMENT OF THE NEW ARCH (WHICH LIES PARTLY WITHIN THE OLD TUNNEL).

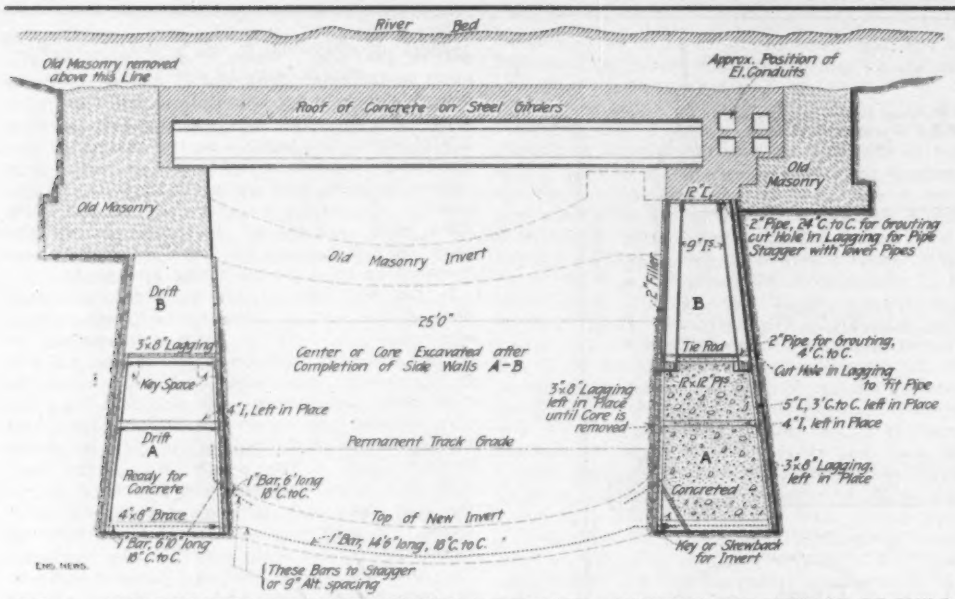

River Bed
Old Masonry removed above this Line
Approx. Position of El. Conduits
Roof of Concrete on Steel Girders
Old Masonry
Old Masonry
12"I
Old Masonry Invert
9"I
2" Pipe, 24" C. to C. for Grouting cut Hole in Lagging for Pipe Stagger with lower Pipes
2" Filler
Drift B
3"x8" Lagging
25'0"
Center or Core Excavated after Completion of Side Walls A-B
B
Tie Rod
2" Pipe for Grouting, 4' C. to C.
Cut Hole in Lagging to Fit Pipe
Key Space
4"I, Left in Place
3"x8" Lagging left in Place until Core is removed
12"x12" Pile
5"I, 3' C. to C. left in Place
4"I, left in Place
Drift A
Permanent Track Grade
Ready for Concrete
1" Bar, 6' long 18" C. to C.
A
3"x8" Lagging, left in Place
4"x8" Brace
Concreted
Top of New Invert
1" Bar, 14'8" long, 18" C. to C.
1" Bar, 6'10" long 18" C. to C.
Key or Skewback for Invert
These Bars to Stagger or 9" Alt. spacing
ENG. NEWS.

FIG. 4. CROSS SECTION OF RIVER PORTION OF TUNNEL; SHOWING THE METHOD OF BUILDING THE WALLS BY DRIFTS, AND UNDERPINNING THE EXISTING ROOF.

on the outer side, but provision was made for grouting all voids outside the lagging on the outer side. For this purpose 2-in. pipes were embedded in the concrete at the bottom and top of the upper section of wall, holes for these being cut in the outer lagging. The lower pipes were 4 ft. apart and the upper pipes 2 ft. apart, as shown in Fig. 4. The removal of the inner lagging after the excavation of the material between the walls exposed the ends of these pipes, which were fitted with screw couplings for hose attachment. Cement grout was forced through each pipe, and the coupling plugged. When the grout had set, the couplings were removed, leaving the pipes flush with the face of the wall.

The material enclosed within the walls and drifts was excavated by hand, and the new concrete invert laid in 3 ft. lengths as fast as the excavation proceeded. The side walls parallel with the temporary drift of the shaft were built in drifts working westward from the tunnel, and the locks, drifts and shaft were then removed.

The material encountered was principally stiff blue clay; it was soft in some parts, but there was little water and only a few quicksand pockets. The excavation in the drifts was done mainly by large draw-knives, each handled by two or three men, vertical strips of clay being cut from the face of the drift for the full height of a man's reach. This work is shown in Fig. 6, with three men handling the knife. The stuff was hauled out in ½-yd. cars on a track of 14 ins. gage (20-lb. rails), and taken up by the elevator to a trestle about 10 ft. above the ground; this extended 100 ft. to the river, where the stuff was dumped into scows.

The mining and concreting in the drifts was carried on in shifts of 8 hours (each including half an hour for lunch). The progress averaged 6 to 9 ft. per shift, or 18 to 27 ft. per day. The force for each mining shift included 2 miners, 2 muckers and helpers, and 2 car pushers; there were also a lock tender and 1 car pusher at the lock; 2 men to handle the cars between the lock and the elevator, 1 elevator man, and 2 or 3 car pushers at the surface to handle the muck cars between the shaft and the dumping platform or the concrete cars between the mixer and the shaft. The tracks made a loop in front of the concrete mixer, for convenience in loading the cars and running them to the shaft without switching. The concreting gang in the drift averaged 2 men to shovel concrete and 2 or 3 men to handle the cars.

The power plant at the west shaft consists of three air compressors (one in reserve) and a 25 HP. hoisting engine, operated by steam from a battery of three boilers. The concrete mixer (with a ½-yd. drum) is located close to the river, so that the materials could be delivered by scows, as the site is hemmed in by railway tracks. The ½-yd. cars used for handling the clay and the concrete have wooden bodies formed by removable sides and ends fitted to steel underframes. With the bodies removed, the cars can be used to handle timbers, lagging, steel posts, etc.

At the middle of the tunnel will be a catch-basin, with a 30-in. drain extending under the invert to the sump of a pump shaft on the east bank, as shown by the profile.

The East Approach.

The side walls for the river end of this approach were built in drifts, following the same methods as described above. The work was of a more varied character than in the river tunnel, owing to the different sections required. At Market St., about 350 ft. from the river, a 7½-ft. shaft was sunk on the center line, in the abandoned inclined approach of the old tunnel. This extended to about 50 ft. below the street, or 35 ft. below datum. From this, short drifts of horseshoe section, 6½ × 7 ft., were run east and west, each ending in a lock followed by diverging drifts, as at the west shaft (and as shown in Fig. 5). Rectangular drifts for the side walls were then driven westward to the river tunnel and eastward to the line of the future subway at Franklin St. The drifts were then extended on each side of the shaft to complete the connection. Part of the twin tunnel also had the center wall built in a drift in the same way. After the completion of the sides and roof, the enclosed material was excavated and the invert built in 3 ft. lengths.

For the double track tunnel with high roof, the walls had to be built in three or four superimposed sections, as shown in Fig. 3, the top of each upper drift being shaped as a skewback, and the steel bracing forming part of the arch truss for roof reinforcement. These two top drifts were outside the walls of the old tunnel, and were driven the full length of this part of the work. The roof was then built in sections of about 6 ft. For each section, an opening about 6 ft. long was cut in each of the old walls, and the steel arch reinforcement erected in the open space of the old tunnel, the bottom lagging being supported by falsework in that tunnel. The 6-ft. section of arch and two skewback drifts was then concreted complete. After this completed section had been set for a sufficient time another pair of 6-ft. openings was then cut about 12 ft. further on, and another section of roof built in the same way. The intermediate sections were then built, until finally the old arch was supported entirely upon the new one, as shown. The open space

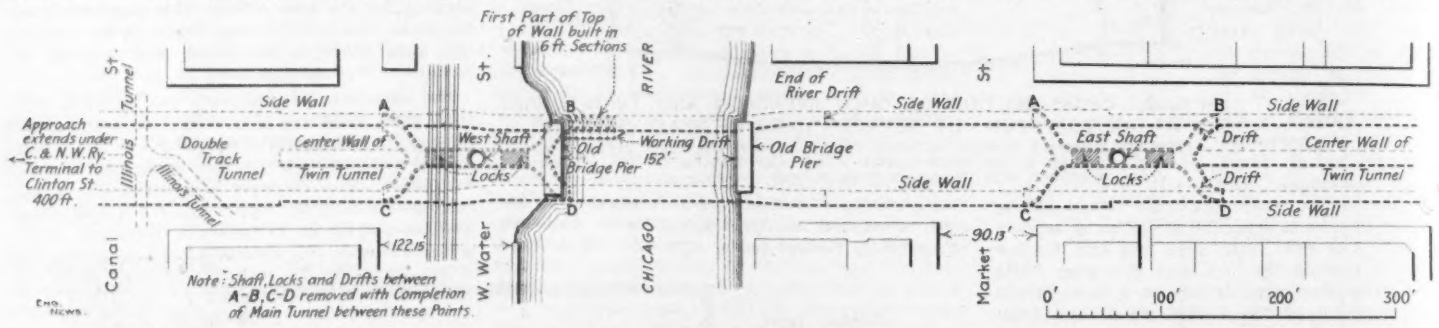


FIG. 5. PLAN OF THE WASHINGTON ST. TUNNEL, SHOWING THE LOCATION OF SHAFTS, WORKING DRIFTS, AIR LOCKS, ETC.

FIG. 6. EXCAVATING A DRIFT FOR THE TUNNEL WALL.
(The excavation is in stiff clay and the three men are handling a draw-knife, making vertical cuts on the face.)

between the new and the old roof arches was afterwards filled with clay.

One of these top drifts is shown in Fig. 8. The floor is formed by the top of the lower drift, and at the left are the first sections of the curved bottom chords of the future arch truss. The roof bracing of the drift is formed by the first panel of the top chord and the first diagonal of

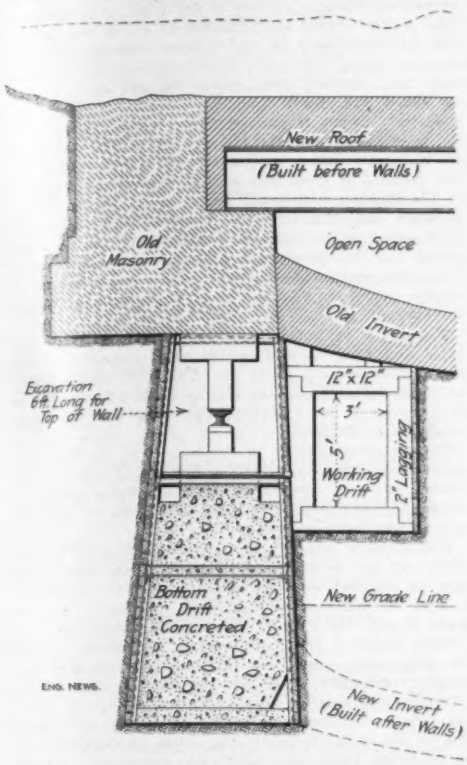


Fig. 7. Side-Drift Method of Building the Upper Part of Tunnel Walls.
(This was used only on a part of the work.)

each truss. This view will be understood more clearly by comparing its lettering with that of Fig. 3.

In the upper part of the work, however, the center wall and roof of the twin tunnel and the floor of the temporary incline above it will be built in open cut. For this purpose steel sheet piling 25 ft. long is driven on each side of the street, outside of the sidewalls already built in drifts. The piling extends a few feet below the tops of these walls. The enclosed material will then be excavated for the full width, the sheeting being braced by inside timbering (in sets 6 ft. apart vertically) as the excavation progresses. The inverts, center wall and roof will then be built in the excavation, and retaining walls built for the temporary open cut to the street surface. Before the piling was driven, a trench was dug on each side of the street to expose any pipes or conduits.

The mining and concreting gangs were about the same as in the river tunnel. The average progress was 6 ft. per 8-hour shift (7½ hours' work), but in the larger drifts an advance of 24 ft. per day has been made, the men having more room to work. The work was mainly in stiff blue clay, with little water and few sand pockets. An air pressure of 10 lbs. was carried in the drifts.

The power plant is erected over the old incline approach, and consists of three air-compressors (one in reserve) belted to a shaft driven by a 25-HP. motor, and a 25 HP. steam hoisting engine with boiler. The concrete mixer is set in the old incline, the cement being delivered by a chute from the store house above, while the sand and stone are delivered by wagons on the street level and dumped through chutes to the storage piles below. The clay and the concrete are handled in the ½-yd. cars described above. To enable the clay to be disposed of without interfering with street traffic a trestle was built from the shaft house along Washington St. (and crossing Market St.), to a dumping platform at the river, a distance of about 350 ft. Here the material is discharged into dump scows. The two 14-in. gage tracks made a loop along the edge of the platform, which had two chutes. The trestle is about 14 ft. high, and has a tight plank floor and plank parapets to avoid any dropping of material, tools, etc., in the street.

West Approach.

From the west end of the river tunnel as far as Canal St. the side walls were built in drifts in the manner described above. For part of the distance also, a third line of drifts was run for the center wall of the twin tunnels, after which the roof was built in 6 ft. transverse sections, within the old tunnel or in open cut, as described for the east approach.

Beyond Canal St., the work was done in open cut for about 330 ft., passing through the foundations of the new Chicago & Northwestern Ry. terminal station. This includes an open incline with concrete retaining walls for the temporary approach coming to the surface at Clinton St., and under this a short stretch of twin tunnel at the elevation of the future subway under Clinton St. (Fig. 2). The work had to be planned so as to clear the columns of the terminal station, the spacing of which is such that they project beyond the face of the tunnel wall. They are encased in concrete. A view in one side of the twin tunnel is shown in Fig. 9, with the steel columns at one side, before the concrete covering was placed around them. It will be noted that the roof arch has the Jackson system of centering with steel ribs and steel panels for lagging. This system was described in our issue of Oct. 22, 1908.

Two rows of 26-ft. steel sheet piling were driven outside the lines of the walls, or about 42 ft. apart, the bottom of this sheeting reaching 3 ft. below the level of the future invert (Fig. 2). The piles were 15-in. I-beams, each having clips riveted to one flange to engage the flange of the next pile. The entire space between the rows of piling was then excavated by hand to a depth of about 40 ft., and for a length of 350 ft. Timber bracing (12 × 12 ins.) was put in at each 6 ft. lift, the cross struts being 8 ft. apart, with 6 ft. posts between them. In this open space the forms were erected for the side walls, the timber struts being either removed for a certain distance or having the concrete filled around them. In the latter case, the subsequent removal of the struts left holes which were filled as required. The longitudinal braces were so placed that the form posts were attached directly to them, which arrangement proved to be very economical and efficient. The walls are braced by transverse steel struts which are encased in concrete, making reinforced concrete struts having a section about 30 × 20 ins. They are supported at the middle by concrete pedestals built on the center wall for the future twin tunnel. The inverts and the lower sections of the center wall could be built without interference with the timber bracing, and were built in lengths of about 45 ft.

The retaining walls are 5 ft. thick, made of 1:2:4 concrete, reinforced at both back and front by vertical 1-in. twisted bars 18 ins. apart and by horizontal ⅝-in. bars 12 ins. apart. The center wall is 2 ft. thick, reinforced in the same way. As noted already, it is planned that the twin arch shall spring from this center wall in the future subway construction, and 67 ft. at Clinton St. has been already constructed according to this plan (Figs. 2 and 9). This arch is reinforced by ⅝-in. transverse bars and ⅝-in. longitudinal bars, each 12 ins. apart.

After the concrete side walls had become set and hard, struts and shores were placed behind them to support the steel sheeting until the removal of the latter. On part of the cut, however, the walls were built by the tunnel drift method already described, without the use of steel sheeting. There was more soft wet clay here than on other parts of the work, and considerable water was encountered, coming from old filled ground, so that there was heavy pressure on the walls. On the outside of each wall is a waterproofing course of brick laid in asphalt. The brick course is covered with 1 in. of asphalt, and outside of this is a 6-in. protecting course of concrete. The space between the steel sheeting and this concrete covering was filled with sand, so that the sheeting might be pulled without disturbing the concrete.

The concrete mixer (driven by an electric motor) was set at the Canal St. end of the open cut, being placed below the street level so that it could be charged by means of wheelbarrows. At first the concrete was handled by drop-bottom buckets on a cableway extending over the center line of the work; the bucket was dumped over a hopper from which lateral chutes were laid to the forms. Later on, the concrete was handled in steel 1-yd. side-tipping dump cars, running on 14-in. tracks, and dumping into chutes which were shifted as required. For part of the work at the bottom of the cut, the concrete was dumped directly into an inclined chute, from the end of which it was led to the forms by portable chutes.

The excavated material was removed by the 1-yd. steel cars and dumped into inclined chutes leading to one of the tunnels of the Illinois Tunnel Co. (7 × 9 ft. inside the concrete lining). Cars were placed in this tunnel to receive the

FIG. 8. COMPLETED DRIFT FOR TOP OF WALL AND SKEWBACK OF ARCH OF DOUBLE TRACK TUNNEL.
(The steel bracing forms part of the permanent reinforcement and also of the reinforcing steel truss for the tunnel roof. [See Fig. 3.])

FIG. 9. SINGLE-TRACK TUNNEL (OF TWIN TUNNEL) WITH REINFORCED-CONCRETE ROOF BUILT ON FORMS COMPOSED OF STEEL RIBS AND PANELS.

(The steel columns at the left are part of the new terminal station of the Chicago & Northwestern Ry. They are to be encased in concrete.)

material, and when loaded were hauled by an electric locomotive to the disposal station of Geo. W. Jackson (Inc.) on the river front. This has shafts just behind the river wall, over which are traveling electric hoists. The car body is hoisted up the shaft, and the hoist then runs out on a track extending over the river; the bottom of the car is then released, dropping the load into a dump scow. The Illinois Tunnel Co. has some 40 miles of these tunnels, at a depth of about 27 ft., and has an extensive business in removing ashes, debris from building operations, etc., in the manner described above.

In part of the approach, the center wall is directly over the Illinois Tunnel Co.'s line. Where the cover over the roof of the latter is less than 3 ft., a concrete block or saddle is built, 13 ft. wide, 7 ft. deep at the sides and 3 ft. deep over the crown of the tunnel.

The 330-ft. length of open-cut approach work was done in three sections of 110 ft. each, in order to permit the re-use of the timber bracing and steel sheeting. This sheeting (described above) was driven with steam pile hammers, and was pulled out after the construction of the concrete retaining walls. At first this was done by a special traveling machine resembling a gantry crane, Fig. 10. The bridge consisted of a pair of heavy I-beams about 70 ft. long, stiffened by truss rods, and resting on structural steel towers carried by wheels on tracks outside the line of the work. On the bridge were mounted two 100-ton hydraulic jacks, with chains having hooks to be attached to holes in the piles. While this was effective, it was rather slow, and a machine for more rapid work was rigged up. This had a timber tripod or tower, with a seven-sheave pulley block attached to the top; a similar block was attached to the hoisting hook, and a cable passed over these to make a seven-part tackle. The end of the cable was led to a hoisting engine, and a pull of about 35 tons could be exerted at the hook attachment to the pile. Most of the piling was removed by this apparatus. The jack machine, however, was required for several piles which the engine could not start; these were usually piles that had been bent in driving.

AN AVIATION EXPERIMENTAL OR TESTING STATION has been established at Breslau, Germany, for the benefit of provinces of east and west Prussia, Posen, and Silesia, according to U. S. Consular reports.

A Vibrating Table to Ensure Homogeneity in Cast Concrete Pieces.

Some years ago it was the general opinion among engineers that the constant vibrating of forms in which concrete was setting would act to delay the period of set and perhaps permanently affect the strength of the concrete. In contradiction to this theory, however, many constructors brought forward examples of good concrete, of sound composition and standard strength, which had set under just such conditions of motion as the theory considered dangerous, such motion, for instance, as that imparted by the shafting of moving machinery attached to the forms. In further contradiction to the old theory, there now comes forward an invention of an English engineer, in which a vibration is imparted to setting concrete in order to cause it to take a better set. This invention is described in "Indian and Eastern Engineer," May, 1910, substantially as follows:

To attain absolute homogeneity in cast concrete products The Improved Construction Co., London, has introduced an oscillating and vibrating table on which the molds are placed, the principle being somewhat similar to the vibrating tables which have been used for repacking teas after blending, and the results attained, as reported, are of the very highest character.

Briefly described, the "Jagger Process," so called after its inventor, Mr. P. B. Jagger, consists in placing the materials to be treated on a "table" or horizontal level platform to which is imparted "a horizontal-vibratory motion, combined with a suddenly arrested rocking movement." The inventor claims that the secret of success lies in the fact that a rapid solidification of the particles takes place before the "initial set" of the cement occurs, and that no mere shaking up of the material will effect the same result or produce an absolutely homogeneous mass equal in density throughout, entirely without air-holes or cavities of any kind. It is explained that in the process of formation all excess moisture in the materials rises to the surface, together with the air that would otherwise remain between the particles, and that, through the peculiar motions of the table, all slimes are ejected from the cement, sand, and aggregates. Owing to such ejection, all deleterious matter is removed, and the concrete is thereby allowed to act uniformly under varying stresses of temperature. By the removal of these slimes, etc., no hair-cracks occur in the finished work when subjected to change of temperature and climate. The motions of the vibrating table acting on the aggregates brings them so closely together that the percentage of voids is greatly reduced, and consequently only the absolutely requisite amount of cement needed to bind the particles together chemically is required.

The speed of the motions is varied, being at first rapid and then reduced as the mass consolidates, and the surplus air and water are thrown off together with all deleterious matter. So rapidly is the effect produced that within 7 to 15 minutes the most complex structures can be finished.

The oscillating portion of the table is so balanced that even when loaded to its full capacity little power is required, not more than 3 effective HP. being needed to work the table when as much as 7 tons of concrete articles are being produced.

The ordinary size of the table is 13 ft. long × 7 ft. wide, and this is sufficient to carry all the molds that may be required to make up to 7 tons of concrete at a time of whatever form desired, but tables can be made of any size to suit various requirements.

When required for making heavy monolithic blocks, the same sized tables can be employed, but they are naturally strengthened to suit the work in hand.

For such articles as piles or girders above the average length, the requisite number of tables are placed side by side so as to enable the molds on trolleys to be rolled across them; the tables are connected mechanically together so that their motions are similar and synchronous, thus forming in reality but one moving platform.

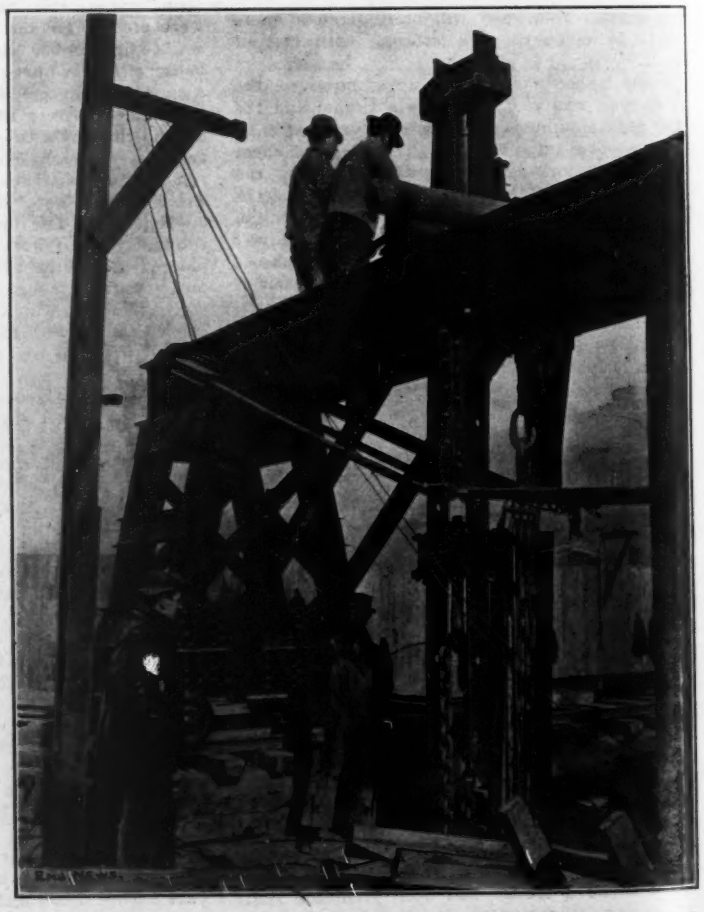


FIG. 10. TRAVELING GANTRY FITTED WITH HYDRAULIC JACKS FOR PULLING STEEL SHEET PILES.

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For thirty years the city of Milwaukee has been struggling with the problem of garbage and refuse disposal. It has tried two different furnaces, two reduction plants, land burial and lake dumping. Recently it put a third burning plant into operation, under far more favorable auspices than have surrounded its earlier experiments. Present indications point to the success of the new incinerator, the design, construction and tests of which are set forth elsewhere in this issue in a lengthy illustrated article by the resident engineer on the construction of the plant, who is now serving as superintendent of operation.*

The earlier refuse-disposal experience of Milwaukee differs from that of most other cities chiefly in variety and degree. It has made a few more experiments and had more litigation with contractors than the general run of American cities. A common cause is the source of most of the unsatisfactory experience with garbage and refuse disposal in Milwaukee and other cities alike. We have stated it so often that we almost shrink from mentioning it again, but feel it our duty to say once more that failure to treat refuse disposal as an engineering problem has been the bane of American cities in general for the past 25 or 30 years, or ever since large populations made refuse disposal a serious matter in this country. This failure has been increased by an accompanying sin of commission: making this municipal service a subject of political chicanery, through contractors and voting laborers.

Milwaukee, in common with a few other American cities, has at last made the design and construction of a refuse disposal plant an engineering problem, and secured able engineers for its solution. It is to be hoped that the city will realize that the operation of its new refuse incinerator is also a task to be conducted on engineering principles, under the direction of a competent engineer. A good start along this line has been made by retaining the resident engineer on construction as superintendent of operation, and we trust that the city will continue the practice, at the same time keeping the whole operation of the plant free from the evil effects of choosing employees on account of political affiliations and of overlooking inefficiency and incompetence for the same unworthy and harmful reason.

As to the Milwaukee refuse incinerator itself, Mr. Greeley's description and accompanying summary of contract-test results speak more eloquently than we can. We would merely call attention to the evident care with which the plant has been designed to meet local conditions at Milwaukee, and to give high temperatures, satisfactory combustion, available heat for power purposes, and general efficiency and low cost of operation. The ventilating system and the separation of the three chief labor operations—feeding, stoking and clinkering—so they will not conflict with each other deserve special consideration on the part of those who may be called upon to design refuse incinerators for other cities.

The efficiency of the plant as to refuse burned per foot of grate surface and steam raised per pound of refuse seem to compare favorably with the best results reported from England and other European destructors, respective local conditions considered.

Assuming that the steam-raising efficiency of the plant in daily and yearly practice proves to be all that the tests indicate, what practical use will Milwaukee make of the heat? This question is an important one to designers of incinerators for American cities, as well as to the cities themselves. Municipal demands for heat or steam from such plants do not seem to be so numerous in the United States as in foreign countries. Moreover, the financial accounts of the foreign combined refuse disposal and power plants do not seem to be kept in a way that shows readily, if at all, just what economies result in trying to utilize the heat from refuse destructors. It is to be hoped that Milwaukee will embrace that opportunity to throw clear light on this subject.

*The history of garbage and refuse disposal at Milwaukee, up to 1902, was given in some detail in Engineering News for Jan. 23, 1902, in connection with a description of the Engel-Robinson garbage furnaces built that year. See also Eng. News, Nov. 1, 1894, for a description of the Merz garbage reduction plant; Jan. 16, 1908, for an abstract of a report by Mr. Rudolph Hering, M. Am. Soc. C. E., on refuse disposal at Milwaukee; and April 22, 1909, for specifications and a tabulation of bids for the plant recently completed.

The failure (by disintegration) of reinforced-concrete slabs forming the roof of the trainshed of the LaSalle Station, Chicago, indicates the necessity of preventing the access of moisture and gases to reinforced cinder-concrete, or the inadvisability of using this material in cases where there is liability of exposure to such influences. The gradual disintegration of these roof slabs has necessitated their renewal over a considerable area of the trainshed, and the methods of repair were noted on p. 763 of our issue of June 30, 1910. It appears upon further investigation that the porous character of the concrete and the use of cinder aggregate were the causes of the failure. The original slabs were about 5 ft. long, 2 ft. wide and 3 ins. thick, reinforced with expanded metal of about 3 ins. mesh and No. 12 gage. The exterior shell was about ½-in. to ¾-in. thick, and was composed of gravel concrete; the interior portion was of cinder concrete, probably for the purpose of reducing the weight of the slab. According to official information, the cause of the disintegration was that the gases and moisture from below penetrated through the gravel-concrete shell and entered the cinders. This led to the rusting of the steel, causing it to swell (or enlarge in section) in places and crack off the concrete. The new slabs are made of stone concrete throughout, and when finished they are treated with a solution which is designed to close and seal all pores, so that neither gas nor moisture can penetrate the facing of the concrete. Whether any thought was given to the possibility of corrosion of the steel reinforcement when the roof covering was designed (some eight years ago) we do not know, but if so it may have been assumed that the ventilation of this lofty arched roof would be sufficient to dilute and carry off any deleterious gases.

The simultaneous announcement in the United States and Canada of official action looking toward the international control of the railway systems common to the two countries is welcome news, both as regards cooperative control of the railways and as pointing the way to joint action in other commercial and industrial matters of mutual interest.

The announcement by the U. S. Department of State that Mr. Martin A. Knapp, Chairman of the Interstate Commerce Commission and Mr. J. P. Magee, Chairman of the Railway Commission of Canada, would confer "on the subject of the joint control of international traffic rates" followed only two days after the decision of the Massachusetts Railroad Commission to allow the Grand Trunk Railway to build a line connecting its Central Vermont terminal at Palmer, Mass., with a line from Providence to the Massachusetts-Rhode Island boundary, previously authorized by the last-named state. The nearness of the dates of the Federal announcement and the State decision is doubtless a mere coincidence, but some may consider it a happy one. Anyway, it is interesting to know that a Canadian railroad is to gain independent access to an important New England seaport, and a pleasure to record such amicable relations between the two national governments and between two state governments and a great Canadian railway system.

Simplicity as a desideratum in railway signaling and signal apparatus was the keynote of some remarks in our issues of June 30 and July 7, in which we pointed out the defects of the present apparent tendency to design intricate and complicated signaling systems without sufficient consideration for their purpose as means of enabling traffic to be handled safely and efficiently. The same view is taken by Mr. E. C. Carter, Chief Engineer of the Chicago & Northwestern Ry., in a paper prepared for presentation at the International Railway Congress, an abstract of which paper is published elsewhere in this issue.

Mr. Carter is well-known in the field of signaling, and is the inventor of important appliances in this line, while his position as chief engineer of a large railway system (which is extensively equipped with block signals and interlocking plants) gives weight to his views. He believes that the formulation of a series of signal indications should be designed with a view to simplicity for the information or government of the men handling high-speed trains, rather than with a view to the multiplication of instructions as to the slower class of trains.

The enginemen have many duties other than looking for signals, and on fast trains there is little time for the series of mental processes by which the man observes a signal, comprehends its indication, and (if necessary) acts upon it. The smaller the number of indications (or combinations of indications) which he has to carry in his mind, the better for the service. Mr. Carter believes that all requirements may be met by a single blade and four indications. He puts the case clearly and concisely, and a careful study of the principles which he presents should result in a check to the movement favoring costly complication of signals and signal apparatus, which movement is based upon a desire (1) to increase the number of indications and (2) to pile one precaution upon another in order to make an absolutely safe system (as far as mechanism is concerned).

As we have said before, greater attention to the men and less to the mechanism would probably result in equal (or even greater) safety and efficiency, with much saving in the cost of purchasing, installing and maintaining the delicate and intricate machinery required in signal equipment. It has been claimed also, that many of the developments in the line of complication have been advocated largely by those who are distinctly "signal engineers," and who are likely

to give insufficient weight to arguments from the operating and economic points of view. Indeed this has been the cause of a sharp separation in the signal committee of the Railway Engineering and Maintenance of Way Association, with the result that at the last annual meeting two reports were presented, one advocating a complicated series of indications, and the other opposing this as being too complicated and not conducive to good service. It should be borne in mind that the sole purpose of signaling is to ensure safety and efficiency in the movement of trains, and anything which goes beyond this or carries it to an extreme is a superfluity which is not only costly but may actually decrease the efficiency without increasing the safety.

Just how many cities are using calcium hypochlorite as a permanent or a temporary means of disinfecting their water-supply to-day it is impossible to say. Certainly the use of that germicide has spread with remarkable speed during the past two or three years. The latest city of considerable population to adopt hypochlorite as a disinfectant is Milwaukee, Wis., where a recent increase in the number of cases of typhoid fever reported to the health department was followed by the use of hypochlorite, beginning about June 21, 1910. Some weeks earlier another lake city, Toronto, began the same practice, for the same general reason, as is described elsewhere in this issue.

One notable merit of the hypochlorite treatment is its great simplicity. A temporary plant for introducing this agent into a water-supply can be installed in a few days—perhaps hours, in some cases—and a reasonably permanent plant can be got into working order in a week or two. Expedition of this sort is exactly what is wanted in the event of sudden suspicion of the water-supply.

Another great merit of water disinfection by hypochlorite is its remarkable cheapness. An average of 25 to 40 or 50 cts. per 1,000,000 gals. of water treated is a liberal figure, according to reports from various quarters, and this includes capital charges (which are low) as well as operating expenses.

Present indications are that the process will continue to grow in favor and use until few cities dependent on unfiltered surface supplies will not employ it—at least for emergency use. Even where water is subjected to a high degree of filtration, hypochlorite is likely to be used at times, particularly in connection with mechanical filters.

The gradual failing and final collapse of the concrete piles under the amusement pier at Long Beach, Cal., as briefly described by Prof. Waterbury on another page of this issue, calls attention to a practice that has had some vogue in the past, particularly on the Pacific coast, and which has lately been proved in several instances to be dangerous. We refer to the practice of building concrete piles, or small piers, in water by depositing the concrete inside of wooden forms from which the water cannot be or is not pumped out. These outside wooden coverings are not removed but are allowed to remain as a partial protection to the concrete until they fall away as a result of natural decay.

In two places along the Pacific Coast, at Long Beach and in several wharves at San Francisco, when, in the course of a year or two, the wooden coverings have rotted away, it has been found that the structure of the concrete in the piles was of extremely poor quality, so weak that it was intrinsically far below its expected and required safe strength and so porous that future rapid deterioration from the chemical and physical attacks of the sea water was invited.

There are at least two reasons why concrete so deposited should not be strong. First, if the pile is located in a strong current, such as exists in the surf at Long Beach, there would be a tendency for the cement in the mixture to wash out through the holes and crevices in the wooden forms. The other is the lack of opportunity for sufficient inspection, both of the depositing of the concrete in the forms, and, on account of the retention of the wooden covering, of the condition of the finished surface. The impossibility of surface inspection is a feature of some kinds of concrete piles for land work, but in such piles there is an opportunity to joggle or tamp the concrete during laying that is lacking in the pile placed in water. Then again, the land pile is not subjected to the same damaging action as are those in the sea, so that surface conditions are not of such importance.

At any rate, whether due to unpreventable structural causes or to a carelessness in construction, fathered by the known fact that thorough inspection is impossible, at least three separate piers founded on concrete piles of this nature have proved unsatisfactory and in each case the type of failure was practically the same. This is sufficient to condemn the method or at least to demand the greatest care in its use in places where no other type of pile seems available. There are so many other ways of placing concrete piles that it is hardly worth while to risk failure by this scheme in order to effect a possible economy. One method only might be referred to here, on account of its similarity to the wooden covering pile of the Pacific Coast. That is the pile employed at the Bocas del Toro wharf at Panama, where a concrete hollow cylinder was slipped over timber piles already driven, the bottom filled with a strong concrete so that the water could be pumped out and the annular space between the wood and the concrete filled tight with a lean concrete, deposited in air. Where any number are to be used these piles should be as cheap as those where wooden coverings are used, and certainly they avoid most of the dangers inherent in the latter.

There is cause for congratulation in the fact that those who attended the New England Conference on Street Cleaning, noted on p. 60 of our issue of July 14, refrained from organizing a permanent society. There are so many technical societies already that it is a relief merely to know that another has not been added to the list. The natural place for the activities of those interested in street cleaning would seem to be the American Society of Municipal Improvements—at least so far as national associations are concerned. Sectional meetings, largely educational in character, can readily take the form of conferences, such as was held at Providence and dealt with in the report already mentioned.

Special Engineering Commissions.

The practice of delegating the study of individual technical problems in public work to special commissions of engineers has grown largely, in recent years. It is one expression of the expanding functions of the engineer in civic life. The importance of technical problems is recognized, and the public begins to appreciate the fact that serious, well-balanced deliberation is needed for solving them. And we can now assert safely that when a distinct technical problem is so broad as to require the larger judgment and knowledge which three or more men will bring to the task—as against the opinion of a single engineer adviser—the commission is the proper thing.

We are here distinguishing between standing commissions or boards—such as a board of health, or the boards of commissioners which administer a drainage or irrigation district—and special commissions. The latter are bodies charged with a specific circumscribed task, whether of study or of construction or supervision. A standing commission, unlimited in length of life, has continuous duty, and usually is of administrative character. The principles governing service on boards of this kind are those applicable to all public service. But in the special commission the service is of pure consultant character, and the individual members occupy a strictly professional relationship to the appointing authorities and (in case of public commissions, which alone we are here considering) to the public. It is because of this fact that a professional interest attaches to the work and conduct of special commissions.

Counting the whole breadth of our country, we discover easily that there are very many of these commissions in the course of a year. They cost a great deal. They delay action on many important matter, pending their carefully elaborated decisions. The general public finds them imposing, but also rather ponderous, and costly, and sometimes feels dissatisfied with them. A slight element of distrust of technical commissions can be perceived; if anything a growing distrust. Looking ahead, we may discern a danger that engineering commissions will come to be regarded as parasitic things; deplorable, like condemnation commissions and similar outgrowths of legal practice. Such a condition cannot be a sound one for the public status of the engineer as a respected and highly necessary professional man.

Even casual reference to the various special commissions coming to notice in public-works affairs reveals some peculiar phases of the situation, and doubtless a fuller study would be yet more instructive and interesting. It becomes evident on a first survey of the field that the growing multiplicity of commissions implies a certain degree of abuse of the commission idea by lay officials, those who initiate and directly employ the commissions. If a mayor, or a city council, appoints a commission where simpler devices—the employment of a single engineer—would secure equal results, then we may speak of abuse. For, the value and importance of such engineering bodies is lowered or cheapened, just as would a court of record when saddled with a police-court case. Such abuse also carries the unpleasant impression that the services and status of the consulting engineer are not ranked very high, in which particular the profession ought to safeguard itself.

A recent case in a Lakes city comes to mind. There, in a proposed piece of public work, a firm of consulting engineers had first been employed, but under instructions not sufficient to establish it as authoritative adviser and technical agent. The firm outlined some general plans, as a means of preparing the city to entertain bids and treat in detail with competing contractors. The result was unsatisfactory, which is not altogether surprising under the circumstances. The firm's general plans were in some respects so specific as to draw criticism (which had a ready opportunity because of the consulting firm's ill-defined status in the proceedings), while in other respects the plans were very general, and threw on the bidders the main responsibility for planning the entire work. It does not seem that the city was any better off in these circumstances than if no consultants had been employed. When bids were received and compared, a contest of words and intrigue began along the whole fighting-line, and the problem in its entirety had to be considered and decided by the bewildered authorities. The chief function of a consulting engineer, namely, to relieve the lay authorities of technical matters and take full charge of the complex preliminaries, was utterly missed.

At this stage a complete reference of the subject to an engineer placed in authority would still have disposed of the difficulties. But instead, the seductive idea of having a commission occurred to somebody. The idea took, and by the best lights of the officials several outside engineers were picked to constitute an advisory commission. It was by no means the purpose of the city fathers to let the control of this interestingly complicated situation get out of their hands; so they did not place the whole problem before the commission, but merely directed the latter to answer two or three specific questions of detail which had been raised during the preceding controversy. Conceivably a high-strung set of engineers might have declined to be thus fenced in, and might have set forth boldly that whatever answers they could make would be only abstract and not of determinative force in the specific case. But the commission more practically, set to work and answered the questions placed before them; to their credit also be it said that they brought in their result very

promptly, which is not always the case with special commissions.

Obviously the local authorities still had the task of making a decision in the matter. The special answers obtained by commission did not solve the problem, but merely restated some of its terms; the decision when made was still the work of laymen. There is a saying that he who is his own lawyer has a fool for his client. It was exemplified here, for the decision of the authorities did not end the discussion—better called squabbling—and has created the prospect that the whole course of the work will be marked by disagreements and by contention. Possibly a consulting engineer may yet be put in direction of the work, though at this stage he can guide the construction operations only, without voice in choosing general plan or details.

Whatever losses come to the public by proceedings of this kind, and whatever derogation of the standing of the engineering profession may result, are to be blamed on the blindness of the appointing authorities. As a safe guide of proper conduct in similar cases, two basic principles may be laid down:

(1) that commissions should be resorted to only in large and comprehensive problems, and

(2) that a commission should never be restricted to a limited phase of a problem, or to a few specific questions, but should at all times have freedom to pass quite broadly on the whole problem in hand.

The non-observance of the latter rule has repeatedly, in the past, fortified a debatable undertaking with the apparent approval of able engineering commissions, though the latter were restricted to particular narrow questions not necessarily determinative of the choice of solution.

But when we say *large* problems we do not mean to convey that mere size of work is sufficient reason for a commission. The determining factor is the need for that broader knowledge, better judgment and discretion, or assurance against individual bias, which are afforded by a group of several men. In the absence of such requirements, the work may be long and detailed and may require a considerable period of time with close attention to detail—yet a single engineer is just as able to carry it out as a commission. Indeed, the commission is apt to be the less efficient of the two. But the contrary is commonly believed, and this erroneous impression is indirectly responsible for much of the dissatisfaction which has been felt concerning technical special commissions.

Almost every reader's knowledge will furnish him an illustration of the inefficient system often prevailing in the work of special commissions: where a commission appointed merely because the required investigation was large, organized an elaborate office force and carried on its labors wholly by means of subordinates. In such cases the occasional meetings of the commissioners for passing on this or that phase of the work are of little importance to the efficiency of the undertaking, and in effect the secretary or other subordinate-in-charge is the concrete embodiment of the commission. Any one of the expert members of the commission, or any other single consulting engineer, could himself conduct the work with vastly greater ability and knowledge than the actual manager—the secretary; but when the able working hand puts on the commissioner's glove its skill is embalmed in formality and indirectness of control.

And there is frequent reason to believe that the supposed impartiality, and freedom from individual idiosyncrasy, of the commission plan of conducting a study is not necessarily realized. A crank member, or a commissioner ambitious for power, succeeds only too often in giving the impress of his personal fancy to the (theoretically) joint production of the commission. Just as happens in committee work, the assurance of efficient and fair result depends on the fairness, energy and harmony of the aggregate; and sometimes the best predictions from the make-up of a commission fail to discover the troublemaker who afterward becomes unpleasantly evident.

That this risk of unbalanced result may be greater than when a single engineer is retained, results from the fact that the commission's report is backed by the united reputation of all its members. The biased commissioner who succeeds in injecting his preferences into the work feels assured that he will not be blamed individually for the result. He appreciates shrewdly that if credit be earned he can draw it to himself, and that dissatisfaction will be easily shifted to his colleagues. The single consultant, on the other hand, stands in the open, and knows that if his work bring either credit or blame it will be his undivided portion.

We spoke above of the danger that engineering commissions might come to be regarded as parasitic institutions. Clearly this is best avoided if every commission will take jealous care not only not to be parasitic, but to avoid the slightest appearance of being so. Recently a commission came to final end which had not avoided this appearance. Years ago an Aqueduct Commission was instituted in New York City, to construct an extension of the Croton water-supply. This, of course, was a definitely limited duty, limited in evident intent if not in terms. But the commission inconsiderately declined to be thus limited, and for many tedious years it spun out its existence, at great cost. Though in recent years it had long outlived its usefulness, it was practically self-perpetuating, and finally had come to be accepted as truly immortal. Some months ago Mayor Gaynor, by bold exercise of a special prerogative, threw the old members out of office, appointed successors with specific orders to wind up affairs and dissolve the Commission, and clinched the matter by having the State Legislature formally wipe out the body. The case throughout affords an example of some things that should be avoided in commission work.

It seems that not all the abuses of the commission idea are the fault of the appointing powers; certainly the above instance lays fault elsewhere. In this connection the point must be remembered that the dividing line between the special commission and the standing commission is sometimes very faint, and a commission of purely temporary function can delude itself into the belief that it has inherently a permanent character. This also tends toward a parasitic effect.

Dilatoriness as a phase of the parasitic quality is so much to be feared that it behooves a special commission to make more haste rather than less. Commissions are rarely appointed on easy, leisurely subjects; their very appointment usually means that the matter is urgent. Should any temporary steps be needed, therefore, the commission ought to recognize the fact immediately, and without delay make report and recommendation on the temporary state of affairs.

It should also hasten its final report, and should avoid the sin of doing too much. The record of public work is dotted with cases in which commission after commission has sat on a given problem, and yet where each has delved into its subject as deeply as though no other study of the problem would be undertaken till the end of time. Perhaps it is for this reason that these oft-investigated problems are usually the ones where a whole generation passes between the first beginnings of the proposed improvement and its final realization. Possibly the long delays chargeable to the commissions mean that they worked too leisurely.

This matter of promptness and of quickly recognizing and reporting urgent phases is so delicate and imperative a part of the duty resting on special commissions that we cite a recent case where, though the commission is probably blameless, yet an unfortunate public impression may result. In a Western city there exists a distant relationship between the water-supply and sewage disposal, of peculiar character, such that it is difficult to prove the city to be permanently secure against contamination of its water-supply. The probabilities are against any contamination, and it has long been a tradition that none could ever occur. Of course, such old traditions are always subject to scrutiny, and when a number of months ago the city appointed an expert commission to study sewage disposal, one might consider that the latent danger of contamination should be an immediate matter of question as to its urgency. No urgency report was made. Yet, before the commission rendered its proper report, conditions arose which suggested a contamination of the water-supply. Should it turn out that the present sewage disposal was in any way responsible, there will surely be grounds for the public to feel deceived. For, after delegating its sewage-disposal problems to the consideration of an expert body, the public might naturally feel that its case was in safe hands; just as a patient under treatment for fracture of the arm will expect his doctor to discover an oncoming attack of pneumonia.

The above scattering remarks on commission work are intended to suggest that every engineer, young or old, ought to give careful attention to the practice of engineering commissions. Even aside from the intrinsic importance of the subject both as a public and as a professional matter, there is a close connection between the ethics of commission work and professional ethics generally; for, the service of an engineer on a special commission is one of the highest forms of professional practice.

LETTERS TO THE EDITOR.

A Defense of Summer Outings of the American Society of Civil Engineers.

Sir: In your issue of July 7 I regretted seeing some remarks signed by a "Member of the American Society" of Boston. It seems to me just as bad to sneer at the American Society of Civil Engineers as to abuse one's own family to strangers, and besides the sneer is not justified. Ninety-nine per cent. of the members probably attend the annual meeting and convention for the sake of social intercourse, and if they don't they had much better stay at home and absorb the printed reports, which they can do in much less time and besides save the expense.

The American Society of Civil Engineers has at least 18 meetings a year in which papers are read and discussed. All offered papers are accepted if they are worth having. Those suitable for discussion are presented to one of these 18 meetings and purely mathematical papers are printed only, instead of inflicting the members present by reading a paper which could be understood by no one, as read—as is frequently done by other societies.

So I, for one, and I know of a great many who agree with me, sincerely hope that the summer meetings in the future will be held in summer resorts only and devoted as exclusively as possible to social functions. "Golf" or even "Baseball" might be the cause of starting or cementing friendships far more valuable than a discussion on Portland Cement or Red Paint, which would probably be much modified in any case before final publication, and I have yet to find any periodical or other publication that is better edited than the Transactions of the American Society of Civil Engineers.

Yours respectfully,

T. Kennard Thomson.

50 Church St., New York City.

WATER-TUBE BOILERS FOR LOCOMOTIVES are discussed in a paper on improvements in locomotive boilers, prepared for the International Railway Congress by Mr. Franz Gerstner, Superintendent of Locomotives and Rolling Stock of the Austro-Hungarian State Railways. The Brotan boiler is the only one of the type which is mentioned. The first of these was introduced in 1901, but there are now 51 in use and 25 are being built. In this boiler, the sides and back end of the firebox are formed by vertical tubes rising from a cylindrical mud-drum; the side tubes are curved to form the crown and are connected to a water and steam drum which extends over the firebox and boiler barrel. The barrel has flanged connections to the steam drum and pipe connections to the mud drums. The weight is about the same as that of ordinary boilers of the same capacity. A disadvantage is that the boiler produces very wet steam due to the small area of water surface, but this may be overcome by using a separator or superheater. The inventor has endeavored to improve this condition by eliminating the upper drum and using a barrel of large diameter, so as to give a large water surface and a large steam space.

A Tabulation of Electrified Steam-Railways and Trunk-Line Electric Railways.

The three tables accompanying, Tables I. to III., giving a statistical list of electric trunk-line ways. They are taken from an appendix to Mr. George Westinghouse's paper on standardizing the electric equipment of railways, printed in abstract in our issue of July 7. The author characterized them as a "forceful presentation of the extent and character of the use which is now being made of electricity in railway service."

These tables are not claimed to be complete, but are intended to give the most important roads. The author states that "only such data are included as were conveniently available;" but the American railways no doubt are correctly represented. He points out also that the horse-power ratings are not necessarily on the same basis in all cases. The figures given are the one-hour ratings, but in some cases these ratings are adapted to the service conditions of the particular railway.

Subway and elevated-railway service is so closely analogous to trunk railway service that from the electric standpoint the former might be included here. Mr. Westinghouse therefore adds a table (not here reproduced), covering the American subway and elevated roads. It includes the rapid-transit lines of Boston, New York, Chicago, and Philadelphia. The total mileage of single track in these lines is 435. They operate 3,659 motor-cars. The power equipment per car ranges from 110 HP. to 400 HP., averaging around 300 HP.

TABLE I.—SINGLE-PHASE OPERATION.

Road	Miles of Line	Miles of Single Track	Line Voltage	Motor Cars		Locomotives	
				No.	h.p.	No.	h.p.
N. Y., N. H. & H. R.R.							
Main Line	21	100	11,000	4	600	41 2	1400 1600
New Canaan Br.	8	8	11,000	2	500		
Grand Trunk R.R.	3.5	12	3,300	...	...	6	900
Erie R.R.							
Rochester Div.	34	34	11,000	6	400	...	....
Colorado Southern Ry.							
Denver & Interurban	46	46	11,000	8	500	...	....
Baltimore & Annapolis							
Short Line	25	30	6,600	12	400	...	....
Swedish State Ry.	7	7	3,300 20,000	2	240	1	300
Midland Ry., England	8.5	17	6,600	1 2	300 360	...	....
Prussian State Rys.	16.5	31	6,600	20 42 54	250 400 345	1	1500
London, Brighton & South Coast Ry.	8.6	17.2	6,000	16	460	...	....
Rotterdam-Haag-Scheveningen	20.5	46.5	10,000	19	360	...	....
Spokane & Inland	129	129	6,600	28	400	6 5	500 720
Midi Ry. of France	75	...	12,000	30	500	2	1600

TABLE II.—CONTINUOUS-CURRENT OPERATION.

Road	Miles of Line	Miles of Single Track	Line Voltage	Motor Cars		Locomotives	
				No.	h.p.	No.	h.p.
New York Cent. R.R.	33	132	650	137	400	47	2200
Pennsylvania R.R.	20	75	650	180	400	24	4000
West Shore R.R.	44	106	650	20	360	...	....
Long Island RR.	42	125	650	137	400	2	1200
West Jersey & Seashore R.R.	75	150	650	68	400	...	....
B. & O. R.R.	3.7	7.4	600	...	...	2.5 5	1600 1100
Northeastern Railway.	37	...	600	...	300	2	600
Mersey Tunnel.	4.8	...	600	24	400	...	....
Lancashire & Yorkshire Railway.	18	60	600	...	600	...	....
Great Western Ry.	5	...	600	...	600	...	....
Metropolitan Railway.	...	67	600	56	600	10	800

TABLE III.—THREE-PHASE OPERATION.

Road	Miles of Line	Miles of Single Track	Line Voltage	Motor Cars		Locomotives	
				No.	h.p.	No.	h.p.
Gt. Northern R.R.							
Cascade Tunnel.	4	8	6600	..	..	4	1900
Italian State Railways.							
Valtelina Railway ..	66	....	3000	10	400	2 7	800 1200
Giovi Railway.	12.4	37.3	3000	..	..	20	2000
Mt. Cenis Tunnel.	4.4	...	3000	..	..	10	2000
Savona Ceva.	...	...	3000	..	..	10	2000
Swiss Federal Railways							
Simplon Tunnel.	13.7	14.3	3000	..	..	2 2	1100 1200
Gergal Santa Fé (Spain)	13.1	14.4	5500	..	..	5	320

Clearance and Grade Requirements for Carrying Highways Over or Under Railway Lines.*

The physical laws for grade separation are summed up in two:

1. The structure carrying the upper line of traffic must be sufficiently high above the lower traffic way to clear all objects passing on the latter;

2. The grade on either traffic way, approaching the crossing, must be practicable for the traffic thereon.

The maximum height of loaded vehicles and any objects thereon on city streets or country highways has been accepted as 14 ft. This height is also sufficient to clear regular street-railway traffic. While higher objects are moved along roads occasionally, it is properly not considered necessary to endanger the practicability of crossings under railways to accommodate them.

The vertical clearance, top of rail to bridge, required over railway tracks is in most cases much higher than over highways, and this constitutes, in the great majority of cases, the insurmountable obstacle to grade separation. The highest fixed projection on an ordinary railway train is the locomotive smoke stack, and passenger cars project higher than the great bulk of freight cars; but some, comparatively extremely few, special freight cars are higher than either passenger cars or locomotive stacks. The extreme clearance requirement is for height, top of rail to running board, of highest car, height of brakeman added thereto, and a further allowance for contingencies, among which may be height of load of light material on an open car exceeding maximum box car height.

There are, at the present time, on the railways of standard gage in the United States, Canada, and Mexico,* about 2,377,282 freight cars of all kinds. They classify as to height, rail to running board, as follows:

Under 12 ft., including flat, gondola and tank cars.	63.1%
12 ft. to 13 ft.	23.4%
13 ft. to 13 ft. 6 ins., inclusive.	11.9%
13 ft. 6 ins. to 14 ft., inclusive.	0.65%
Over 14 ft.	0.95%

Limits of car dimensions are fixed by clearance outlines on the various railways. A composite clearance limit diagram for ninety railways, including all Canadian Trunk lines, has a height of 14 ft. 6 ins., limiting "over all" height of cars to this figure and practically limiting height of top of running board of freight cars to 14 ft. In the St. Clair tunnel, Grand Trunk Ry., the clearance height at width of 3 ft. is 14 ft. It is true that on many divisions or branches of the lines considered, the clearance is somewhat greater than shown in the composite diagram referred to, while on the other hand, it is less on a number of main lines, and on many branch lines.

The limit of grade, approaching crossings, can for railways be taken as between 0.5% and 1%. For city streets a grade of 5% is in most cases extreme and it should be so for main country highways. A preferable maximum grade for roads is 4%, and 3% is materially better. This works out as follows:

For 5% grade 20 × 2 = 40 ft. length of approaches for every vertical foot of clearance.
For 4% grade 25 × 2 = 50 ft. length of approaches for every vertical foot of clearance.
For 3% grade 33 ft. 4 ins. × 2 = 66 ft. 8 ins. length of approaches for every vertical foot of clearance.

Any gain, by curtailment of vertical clearance requirement, or by change of railway grade, or by both, means corresponding shortening of road approaches, at the high ends. Such a gain of 1 ft. may greatly reduce the cost of a given grade separation, making it practicable when it would not otherwise be so. A vertical gain of 2 ft. would mean a very large addition to the number of practicable grade separations.

The extreme allowance that should be made for brakemen on a car must not exceed 7 ft.; 6 ft. 6 ins. will clear any brakeman unless he should be over 6 ft. tall, and 6-ft. brakemen are not common, to say the least. The necessity for brakemen on the tops of cars is becoming less and less, and has in many cases disappeared, rules and regulations of railway companies to the contrary notwithstanding. The air-brake is now universally used in train control.

The Pennsylvania R. R. makes it a rule to avoid all grade crossings on new work, and has within the last nine or ten years eliminated over 50% of all [illegible] grade crossings on main lines. To do this clearance must be made as low as possible. Overhead bridges are [illegible] low as 16 ft. 6 ins. above the top of rail, while many [illegible]re 18 ft. 6 ins. and less. Twenty-one feet, the standard for signal bridges, is recognized as the highest clearance for which there can be any need. In New York State many overhead bridges are only 18 ft. above the top of rail, and this is the case also in Massachusetts and in other states. The New York Central & Hudson River R. R. has asked for 16 ft. or 16½ ft. clearance for all overhead bridges within the electric zone, excluding 16 miles from the Grand Central Station, in the City of New York.

It is submitted that with conditions as they are and more so with regard to the future, 20 ft. (1[illegible] ft. for car and 6½ ft. for man), is a reasonable vertical clearance. It has been shown that 13½ ft. covers the height to running board of all but a very small percentage of freight cars now in use, and that cars higher than 14 ft. to running board, i. e., higher than [illegible] ft. 6 ins. "over all," or to top of brake rod, can only to a limited extent traverse beyond their home railways. That higher cars will be economical or practicable is as little probable as that the gage of railways will be widened or their entire structure changed. For a vertical clearance requirement greater than 21 ft. (14 ft. plus 7 ft.), there can, in any event, be no conceivable rational need.

In Massachusetts there is a special Grade Crossing Commission. The minimum clearance required by this Commission is in general 18 ft. Connecticut and Rhode Island also specify 18 ft. In New York the Public Service Commission requires 21 ft. clearance where practicable, many lower bridges are built throughout the state, some, as already stated, are as low as 16½ ft. New Hampshire, Ohio and Indiana require 21 ft. The only states requiring more are Illinois and Vermont, where 22 ft. is specified, but exception is made where this height is not practicable.

In Canada the Dominion Railway Act of 1904 specifies a minimum clearance of 22 ft. 6 ins. above rail level (allowed to mean base of rail) for bridges over railways, with no deviation except by leave of the Board of Railway Commissioners; and this board has hitherto not allowed a deviation in any case.

MUNICIPAL OWNERSHIP OF STREET RAILWAYS by the City of San Francisco appears to have been held as within the legal rights of the city by a decision of the State Supreme Court in a case brought to prevent the construction of the proposed municipal railway on Geary St. (see Eng. News, March 17, page 314). Bids for the first installment of bonds were to be opened on June 26, 1910, the day following the handing down of the decision.

*From a paper by W. H. Breithaupt, M. Can. Soc. C. E., read before the Canadian Society of Civil Engineers, March 18, 1910.

*Official Railway Equipment Register.

A Review of Modern Signaling Practice on American Railways.*

By E. C. CARTER,† M. Am. Soc. C. E.

A review of the conditions existing in the United States at the present time, with reference to the operation of switches and signals, develops the following:

Centralized installations for operating switches and signals are limited to (1) those in which the required movements of the functions are made by manual force through mechanical connections brought to a central point and (2) those in which some form of stored power is controlled from a central point for such operation.

The first is represented by the mechanical interlocking mechanism which is in such general use throughout the world as to require no particular description. There has been, in America, very little, if any, change in the details of the apparatus or of its installation for a number of years. The use of 1-in. pipe connections is universal for the operation of switches, movable point frogs, drawbridge couplers, and their respective locks, compensated for the effects of temperature changes by an equalizing system of cranks and levers. It is also very generally used for the operation of home signals. Wire connections (one wire for the front connection and one for the back) are still used for the operation of distant signals which can be located not over 1,300 to 2,000 ft. from the tower. But when the signal has to be located at a greater distance, liquid carbonic acid gas (stored in steel bottles) or electricity (derived from a battery) is used as the source of operating power, located at the signal and controlled electrically from the tower.

The second comprises those in which hydraulic, pneumatic, or electric power is stored and used for the operation of the various functions. Owing to the severe climatic conditions which continue in winter for from two to four months throughout the northern portion of America the use of hydraulic switch and signal apparatus is subject to such derangement and such interruptions in operation as to be very unsatisfactory. A small number of plants of this type have been installed but have been discontinued and replaced by other kinds which are free from the troubles which are inseparable from the use of liquids as a means of power transmission under such climatic conditions.

The use of compressed air has been quite extensive and has given a very fair degree of satisfaction as the means for operating switch and signal installations in this country. This kind of power application is represented by two types: (1) low pressure, in which the air is used at a pressure of from 15 to 25 lbs. per sq. in., and (2) high pressure, 80 to 100 lbs. per sq. in.

The low-pressure type has many points of excellence, but for some reason has not become very popular, probably on account of the great number of pipes leading to the switches and signals. Inquiry develops the fact that no plants of this type have been installed since 1905 and also that, as the existing plants require extensive reconstruction or renewal, this type is giving place to some form of all-electric apparatus.

The high-pressure type is represented only by the Westinghouse electro-pneumatic system. A very large number of plants at large and complicated junction points and terminals have been installed and are in very satisfactory operation throughout the entire country. It is a recognized fact, however, that compressed air under high pressure is subject to a number of characteristic losses in efficiency, which will limit its use. The loss on account of the heat generated, due to the work of compression, is unavoidable and amounts to from 50 to 60% of the energy expended in storing this kind of power. The losses due to leaks in the distributing pipes are variable but increase as the system grows older, and often become an element of serious expense, necessitating extensive repairs and renewals.

The application of all-electric interlocking plants has made rapid strides in the last eight or ten years and, as this type offers very superior advantages, it bids fair to take the lead. The reasons for this are: (1) greater flexibility in application and use; (2) in the storage of the power and its distribution the losses can be reduced to a very small figure; (3) the distribution and application of the power is free from any inherent troubles due to variations or extremes of temperature.

This type of interlocking development is represented by the product of four principal companies. The common feature in all of the designs is the use of motors for the movement of switches by means of gears, a screw, a worm or by a cam motion plate, any one of these mechanical devices being susceptible of development to meet the requirements. Signals are operated generally by motor driven gears, dwarf signals sometimes being operated by solenoids.

All power interlocking is arranged so that the completion of the movement of the switch or signal gives a return indication at the machine in the tower, releasing the mechanical locking and insuring that the position of the switch or signal, as the case may be, corresponds with that of the operating lever.

The locking between the levers of the machine is mechanical, being generally of the same type as that for mechanical interlocking plants, though not made nearly so heavy, not being called on to withstand such applications of force as is usual in the manipulation of mechanical levers.

Electric locking of the levers in the interlocking machine may be arranged to effect the following in either mechanical or power operated plants:

(1) Advance Locking.—This is generally used at points where trains pass at high speeds, to prevent the taking away of the route which has been cleared for an approaching train, the switch levers remaining locked until the train has passed or until the signalman has operated a releasing device which is arranged to take time, thus requiring deliberation and giving an interval during which the train can be stopped. The signal levers are never included in this advance locking but can, in their proper rotation, be restored to their normal positions at any time.

(2) Detector Bar Locking.—Electric locking is used for this purpose in connection with track circuits in yards where such circuits are used in place of mechanical detector bars.

(3) Route Locking.—This form of electric locking is used to lock all switches in a route so that they cannot be moved in advance of a train after the train has accepted the route, even though the mechanical locking on the machine has been released by the leverman in placing his signal lever in the normal position.

(4) Release Route Locking.—This form of electric locking effects the consecutive release of each switch as and after the rear of the train has passed it, and is only used in large and complicated terminals to save time.

(5) Check Locking.—This is the form of electric locking between adjacent interlocking towers which are so near each other as to call for cooperative action of the signalmen in them.

Route Levers, as known in Europe, have never become popular in the United States, it being considered an essential operating requirement that the plant should permit of any possible route combination of switches being given so as to cover irregular movements and emergencies.

Switch Locks.—The use of track circuits in place of detector bars has become usual in complicated terminals and is considered as being safer than any mechanical devices for this purpose, it being possible with such circuits to prevent the movement of the switches while the train is passing over them, and may be arranged so that the train is wholly clear of any adjoining track or switch before another train can be permitted to pass that point. In plants where the spacing of the switches is such as to permit it, mechanical detector bars, either inside or outside of the rail, are still generally used, though it is evident that, with the increasing use of heavier rail sections which have materially wider heads, such use must be limited to bars of the inside type.

Auxiliary Apparatus at Passenger Terminals.

In heavily worked, large, and complicated terminals a miniature track model is generally provided on the interlocking machine for the information and convenience of the levermen. Formerly, this model was arranged to show the movement of the switches corresponding to the movement of the levers, but with the greater perfection of the return indication apparatus which controls the operation of completing the stroke of the lever, the model has been used to indicate the occupation of tracks or of two or more sections of a track as may be needed. An indication is often provided showing the failure of any train to wholly clear an adjoining track.

One of the most complete and elaborate installations of this later type is that provided for the operation of the new union terminal at Washington, D. C. Each standing track in the station has an independent track circuit fed through a resistance from a single supply circuit, the track relays all being in the tower at the outer end of the yard. In the tower and over the interlocking machine is arranged a large track model, covered with ground glass, on which the track arrangement of the station is outlined. So long as a track is unoccupied and is not fouled by cars on an adjoining track, that particular track on the model is illuminated from behind the glass. As soon as it is occupied by a car or train the lights are extinguished. It will be seen from this that these indications are given from a closed circuit, which is used preferably on account of its indicating at once any derangement in the circuits and is generally considered to be the only safe way in which track circuits for this or any other purpose can be used.

This station is also provided with a very complete system of communication between the director of the interlocking tower, the train conductors on the different departure platforms and the gateman controlling the admission of passengers to those platforms. In the interlocking tower, in front of the director, there is a bank of indicator lights arranged one above the other, three for each track, the upper light being the return indication from the train conductor, the middle light an indication to the conductor and the gateman, and the lower light an indication from the gateman. Adjoining each gate there are two incandescent glow lights on the circuit, one above the other, connected in such a way that the gateman, by inserting a special key, can complete a circuit to the tower.

At four points, distributed along the platform, are located boxes on the columns supporting the umbrella shed, each box having two glow lights, one above the other, the boxes being so arranged that the conductor of a train, by inserting a special key, can likewise complete a circuit with the tower. The method of using this system of communication is as follows:

One minute before the departure time of the train, the conductor inserts his key in one of the boxes on the platform and turning it closes the circuit which lights the upper light for the corresponding track in the bank of lights in front of the tower director and likewise lighting the upper of the two glow lights at the gate. If the director is ready to have the routes given for this train, he presses a button which puts out the top light given by the conductor and lights the one next below it and lights the top light in each of the boxes along the platform and puts out the upper and lights the lower of the two lights at the gate. When the time has arrived for the train to go, the gateman closes his gate and with his key puts out the light at the gate. This also puts out the upper and lights the lower of he tower indicator lights, in this way advising the conductor and the towerman simultaneously that the train may leave. The conductor may then give his usual starting signal to the engine runner to go, which he then does, provided the proper fixed signal is clear. This arrangement provides a very simple and accurate system for transmitting the required information and works perfectly.

The use of diagrams for facilitating the full utilization of tracks along passenger platforms has been investigated, but enquiry of the roads in this country having the largest terminals develops the fact that no such diagrams are used or are considered as being necessary for the distribution of trains at platforms, experience having proved that the familiarity of the director in the tower with the station lay-out and the information which he receives in advance as to the trains to be handled is such that the desired results can be better obtained by relying upon his skill.

Developments in Signal Practice.

It will be interesting to present a discussion which has been under consideration by those interested in signaling of the various railways of the United States during the last three years. In general, the practice in America has been to give the indications of fixed semaphore signals for both interlocking and automatic block signals in the lower right-hand quadrant, usually by two positions, the home signal being horizontal for "stop" and diagonally downward or vertically downward for "proceed," and the distant or caution signal (the end of the blade being of a different form from that of the home signal, being notched or fish tailed, whereas the end of the home signal is square) indicating in the horizontal position "caution" and diagonally downward or vertically downward indicating "clear."

The extensive application of automatic semaphore block signals and the attempt to carry the block working through more or less complicated interlockings has led to considerable diversity of practice on different lines, and the automatic block semaphore, both home and distant, being of the same form as the home and distant semaphores for interlocking plants has led most naturally to a possible confusion on the part of the engine runner in the interpretation to be given for a given signal indication, especially when in its normal position, which, for an interlocked semaphore indicates "stop and stay" and for an automatic block signal semaphore indicates "stop and proceed with train under control."

The practice on different roads in connection with interlocked semaphores at points where a number of routes are to be indicated has also varied, a number of the older lines having a home signal blade for each route, placed one above the other on a single mast, and other roads for similar situations having only two, the upper for the main high speed route and the lower for diverging routes.

Figure or letter indicators combined with the lower blades under the two blade system have been tried but were discarded as of no value corresponding to the complication or cost due to their use.

The consolidation of different railway properties under one management has brought together lines having both systems in use, and the necessity for unifying the practice over the whole of such a consolidated line and doing it in such a way as would provide for the future as well as the present requirements, led to a very prolonged and exhaustive investigation by committees appointed by the larger lines interested in the question, and later by committees of the Railway Signal Association and Maintenance of Way Association. The result of these investi-

*Abstract of a report prepared for the International Railway Congress, held at Berne, Switzerland, July 4-16, 1910. It is given in full in the March number of the "Bulletin" of the International Railway Congress Association (Brussels, Belgium).

†Chief Engineer, Chicago & Northwestern Ry., Chicago, Ill.

gations was the statement of a series of fundamental principles and of the rules which should govern any applications under those principles.

(1) The first and most radical departure was the use of the upper right-hand quadrant for giving signal indications, in this respect following the German practice. (2) The giving of three indications by one signal blade (in a horizontal position and pointing to the right, pointing upwardly at an angle of 45°, and pointing in a vertical direction upward.) (3) The use of a second blade below the first, which in turn gives three indications by similar positions to those of the first or upper blade. (4) The distinguishing of interlocked semaphore signals from automatic semaphore signals by having the ends of the interlocked signal blades (when the blades were in a horizontal position, in the same vertical line, and by having the ends of the automatic semaphore signals (when the blades were in a horizontal position) so arranged that the upper blade projected further to the right than the lower blade. The night signal lights were correspondingly arranged, one being vertically above the other for interlocked signals and for automatic signals the lower light being located diagonally below and to the left of the upper light.

The above combinations of three positions for two signals permitted of giving a considerable number of indications which were thought necessary for giving information to direct the movement at the high speeds at present required for through limited and special service trains.

It is generally admitted that the night indications should be given by lights of distinctive color, and the difficulty in giving so many combinations as above required has been solved by the use of green, yellow and red lights for the three positions of vertical, 45°, and horizontal. It appears to the writer that by far the most logical solution would have been (1) green, (2) red-and-green, and (3) red for the corresponding positions, the red and green from one source of light having been proved by years of use on one or two of the largest systems in the country to be absolutely distinct and reliable.

Up to the point where two blades have been decided on for giving indications in combination, there has been a fair degree of unanimity in the ideas of those responsible for the system, but some divergence of opinion has developed as to the system by which the combinations shall be made, and the great danger appears to be that greater confusion may result as between the practice of different roads in this respect than has existed under the systems which have been in use heretofore.

Simplicity of Signals; A Single-Blade System.

It is the writer's opinion, that simplicity should never be sacrificed in so grave a matter as giving indications for governing the runner of high-speed trains, in order to give modifying instructions for slower speed movements. The time for correct action by the runner of a high-speed train is so short that the message to be conveyed by signals must be so simple that its interpretation is intuitive and not the result of reasoning. The message, therefore, must be limited to that which can be instantly comprehended by any one who can be expected to reach the position of runner and not by the highest, or even the average mental development to be found in runners as a class.

It is the firm conviction of the writer that, taking into consideration all of the conditions surrounding the men whose duty it is to run an engine, the care of the machinery, the looking out for train order, block, and interlocking signals, the graduation of power for grades and curves, taking water at speed, station stops, and a great many other exacting requirements, the placing upon them of the responsibility of correctly interpreting a combination of signal indications which takes a variety of mental operations, is a long step away from safe practice. It would seem much safer to give the indications by one blade, which, if need be, can have four positions with corresponding night indications, four appearing to cover all present requirements, the blade pointing to the right of the signal mast as seen by an approaching train whose movement is to be governed by it:

(1) Horizontal position, red light at night; (2) vertical position upward, green light at night; (3) inclined upward at 45°, a red and green light at night; (4) inclined downward at 45°, a yellow light at night.

The corresponding indications would then be as follows: (1) "Stop" signal; (2) Clear signal: "Proceed," next signal is also in position to be passed, being either clear or at caution; (3) Caution signal: "Proceed at such speed as will admit of stopping at next signal, which may be at stop or at caution"; (4) Caution signal: "Proceed at such limited speed as is safe to take a diverging route from the main line from this junction or cross-over."

As discriminating between semaphores for interlocking and those for automatic block signals, there can be placed upon the mast a bracket projecting to the left, whose outer end shall have the same relation to the mast that the outer end of the semaphore casting has to the left of the mast for interlocked signals, and on the outer end of which a white light can be placed at night as a marker. For automatic block semaphores this bracket can be projected further to the left so that its outer end will appear to be materially further from the mast than is the semaphore casting upon that side and on the outer end of which a white light can be placed at night as a marker.

It is believed that such an arrangement of signals as this can be made to cover all of the necessary moves in territory where high speed is permitted and that in terminals or other points where the speed is necessarily limited, as compared with that on the open road, a dwarf signal indication can be given on the ground at the foot of or below the high speed signal to meet any additional requirements as to movements of trains at such points.

It will be seen from the above that the mental operations which the high speed runner would be obliged to carry out are limited to not more than four at the instant that he observes the signal, his rule being: (1) stop if a red light or a horizontal blade is displayed; (2) proceed if a green light or vertical blade is displayed; (3) reduce speed as is necessary if a red and green light is displayed, or the blade is pointing 45° upwardly; (4) reduce speed if a yellow light is displayed or the blade is pointing 45° downward.

Having got his train under control, he then has ample time to further consider the movements which correspond with the kind of signal and with the location on the road.

Relation of Headlights to Signals.

As a matter of information in connection with the use of interlocking and block signals in the United States, the following statement will prove most interesting.

During the last two years, a wave of legislation has passed over the United States having for its aim the compulsory use of electric headlights on locomotives and, although the railway managements presented the strongest arguments against such a requirement, many of the states passed the bill and made it a law.

There is no doubt but that the use of the electric headlight largely diminishes the distinctive character of night indications of block and interlocked signals. On lines of single track the condition will be serious enough but where there are two or more main running tracks the electric light blinds the runner of an approaching train on an adjoining track so that for an appreciable time after having met the train the eye cannot tell one colored light from another. It is a question still undetermined whether the continued repetition of this blinding effect will not seriously impair the vision and thus reduce the period of the runners' safe employment on lines where the highest speed trains are guided wholly by block and interlocked signals. While there is no chance for a repeal of this law for one or two years in those states where it has been adopted it is hoped that other states will not follow their example and that experience will lead in due time to the elimination of this unfortunate and even dangerous legal requirement.

Summary.

Summarizing the situation as regards interlocking in America: (1) application of power interlocking is rapidly increasing; (2) electro-pneumatic and purely electric systems are superseding all other forms of power interlocking; (3) the track circuit, with electric locking, is superseding mechanical detector bars; (4) all forms of electric locking are being generally used in connection with heavily worked terminals and in heavy traffic territories; (5) diagrams for facilitating the full utilization of tracks along passenger platforms are not used in the United States.

THE ANCIENT CITY OF TARSUS, ASIA MINOR, has just been provided with an electric lighting plant, according to a report from U. S. Consul Edward I. Nathan, of Mersine. An 80-HP. turbine driven by water from the Cydnus River supplies power for the plant.

Utilizing Waste Heat from Gas Engine Plants.*

By JOHN T. FAIG.†

The designer of steam plants finds a wide variety of auxiliaries in the market. Open and closed feed water heaters, surface, jet and barometric condensers, steam heating and drying coils, cooling towers for water, and water softening plants of many types are available. From these he may select elements which will give the most desirable combination for the particular problem he has to solve.

In many cases the installation of such auxiliaries makes possible a higher net economy than can be obtained with internal combustion engines without auxiliaries, notwithstanding the higher thermal efficiency of the latter engines. This is particularly true of large office buildings, where the exhaust steam may be used for heating, and factories, where it may be used for heating or industrial purposes requiring low-pressure steam or hot water.

Two sources of great heat waste occur in internal combustion engines: The jacket water and the exhaust. This waste is so common that there is danger of losing sight of its importance. The amount of heat so lost varies in different engines, but is nearly always three times as great as the amount converted into work in the cylinder. The table [at the bottom of the page] shows the percentages of heat of the fuel lost in some engines.

Except for the Gueldner engine, which gave such remarkable economy as to be exceptional, the tests showed that about 25% of the heat of the fuel was represented by the indicated horsepower. Practically all the remaining 75% was lost in the jacket water and exhaust. As these tests were made on engines in good condition,

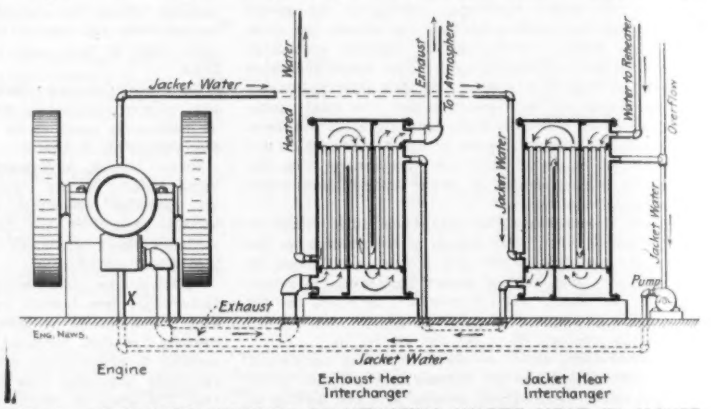

FIG. 1. PROPOSED METHOD OF UTILIZING WASTE HEAT IN JACKET WATER AND EXHAUST FROM GAS ENGINES.

and were considered good enough to go on record, there can be no doubt that the losses of heat in the jacket water and exhaust for every-day engines will be considerably greater. Beside the losses already mentioned, there may be mentioned the mechanical friction of the engine and the radiation, which are inevitable and constitute together not more than 5% of the heat of the fuel. The mechanical friction is, of course, included in the indicated horsepower.

Not only is the heat of the jacket water lost in most cases, but its removal entails considerable expense, that is, the cost of the jacket water itself. There are, it is true, some few installations where the jacket water is used for heating or industrial purposes, but these are merely exceptions to the general run of plants.

The development of auxiliaries that will utilize the heat of the jacket water and exhaust gases must keep pace with the development of internal combustion engines if these engines are to compete with steam engines where the exhaust is used. Where hot water for heating or industrial purposes is required the utilization of most of this waste heat presents no great difficulty. Fig. 1 represents an engine with two simple heat interchangers, one using the jacket water and the other the exhaust gases. The jacket water is used over and over. The water to be heated must have sufficient pressure to overcome friction of passage through the interchangers.

*Abstract of a paper read before the National Gas and Gasoline Engine Trades Association, Cincinnati, Ohio, June 15, 1910.

†Professor of Mechanical Engineering, University of Cincinnati, Cincinnati, Ohio.

HEAT LOSSES IN INTERNAL COMBUSTION ENGINES.

Fuel.	Name of Engine.	Rated Brake HP.	Heat Converted into Work in Cylinder.	Heat Lost in Jacket Water, Exhaust and Radiation.	References.
Illum. Gas...	Gueldner.....	20	42.7%	57.3%	Test by Schroeter, Z. d. v. d. I, 1904.
Nat. Gas.....	Walrath.....	75	27.1%	72.9%	Geer and Venelain, Sib. Coll. Thesis, 1902.
Prod. Gas....	R. D. Wood..	300	24.4%	75.6%	Goldsmith and Hartwig, Sib. Coll. Thesis, 1905.
Kerosene.....	Hornsby.....	25	21. %	79. %	Robinson, 1908, Gas and Pet. Eng., p. 710.
Prod. Gas....	Fair. Morse..	25	25.8%	74.2%	Jahnke, Univ. Cin., Thesis, 1910.

The same idea may be expressed in many different designs. There is no reason why one interchanger should not be placed on top of the other, or the two combined in the same shell. One form of interchanger has recently been put upon the market.

Some firms use part of the heat of the exhaust for vaporization of water for the producer. The writer has given some attention to the utilization of waste heat from producer-power plants and has designed a plant utilizing practically all of the heat in the coal, except the inevitable losses of hot ash, mechanical friction and radiation, all of which may be reduced to very small percentages of the total.

The interchangers may be of the simplest construction, since all pressures are small and temperatures comparatively low, the highest being that of the exhaust gases, from 600° to 1,000°. A thermostatic valve could be installed at (X) to automatically admit cold water from the city mains should the temperature at (X) rise too high. This might occur if for any reason the circulation of the water being heated should be stopped. The exhaust gas interchanger should form an excellent muffler. The exhaust pipe between the engine and interchanger should be covered to reduce heat loss to maintain a reasonable temperature near the engine and to prevent burnt hands.

Fig. 2 shows an interchanger using the jacket water of an internal combustion engine to heat water. The jacket water is used over and over. The heated water

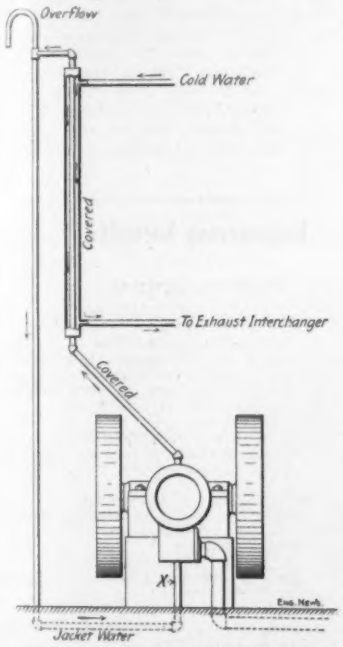

Fig. 2. Alternative Method of Utilizing Waste Heat in Jacket Water from Gas Engines.

passes to an exhaust interchanger, similar to that in Fig. 1, to be further heated. This arrangement does away with the necessity for a circulating pump in the jacket water line. A thermostat controls the admission of cold water to the jacket water line and will operate if for any reason the interchanger does not absorb sufficient heat from the jacket water. The jacket water interchanger may be secured against a wall overhead to save space if there is sufficient head room. The height which will give the proper circulation for a given engine could probably be determined only by trial.

Statistics of Building Operations in The United States.*

The cost of building operations in 51 cities that reported to the U. S. Geological Survey for the past three years was $646,059,835 in 1907, $566,165,404 in 1908, and $771,937,564 in 1909; an increase for 1909 over 1907 of $125,877,709, or 19.48%, and over 1908 of $205,772,160, or 36.34%. The estimated cost of building operations in these cities in 1906 was $700,000,000, so that there was an increase in 1909 over 1906 of more than 10%.

The increases and decreases for individual cities in 1909 as compared with 1908 are not very significant, because 1908 was not a normal year. The largest increase reported for 1908 was $8,141,720, or 13.78%, by Chicago, and the next largest was $4,446,709, or 3.92%, by New York; the increases in 1909 by these two cities were, respectively, $28,003,580, or 41.65%, and $08,228,-995, or 57.91%. Brooklyn, which had the largest decrease ($25,427,604) in 1908, showed the third largest gain in 1909—$18,402,061. Of the cities that showed decreases in 1909, San Francisco had the largest, $5,-484,273, or 17.32%. The significant decrease in San Francisco indicates that the building activities of that city have probably reached a nearly normal condition after the abnormal condition following the great fire of 1906. The annual cost of building operations in San Francisco for the last five years has been as follows: 1905, $18,268,753; 1906, $34,927,396; 1907, $56,574,844; 1908, $31,668,341; 1909, $26,184,068.

*Portion of an Advance Bulletin of the U. S. Geological Survey.

REPORT FOR 1909 ONLY.

For the first time an attempt was made to collect statistics of the building operations by character of buildings and also by additions, alterations, and repairs to each class of buildings. Figures reported from 128 cities gave details showing the kinds of buildings erected and the additions, alterations, and repairs to each class of buildings under 264,536 permits at a cost of $903,385,954, the new buildings constituting 90.3% of the cost and the additions, alterations and repairs 9.7%. Of the cost of these new buildings, 73.24% was for fire-resisting buildings and 26.76% was for wooden buildings. Of the total cost of additions, alterations, and repairs, 65.55% was for fire-resisting buildings and 34.45% was for wooden buildings. The average cost in 1909 for new wooden buildings was $2,269; for new brick buildings, $9,522; for stone buildings, $11,679; for concrete buildings, $17,099; and for miscellaneous fire-resisting buildings, $63,890.

Seattle had the largest number of new wooden buildings, 7,355, and Los Angeles was second, with 5,284 buildings. Chicago was the leading city in cost of wooden buildings, with a total of $13,532,880; San Francisco was second, $12,257,683; Seattle was third, $9,-843,805. New York reported the construction of fire-resisting buildings at a cost of $181,918,337; Chicago was second, with a cost of $79,105,500; Brooklyn third, $54,658,721; Philadelphia fourth, $42,570,770; St. Louis fifth, $22,422,929, and San Francisco sixth, $13,124,987.

Out of the 128 cities considered, 79 erected new concrete buildings, 1,791 in number, which shows the widespread use of this material.

Concrete Laying at the Gatun Locks, Panama Canal.*

When the concrete workers at Gatun had ceased their labors for the day on June 27, over 500,000 cu. yds. had been laid in the Locks at that point since the beginning of operations on Aug. 26, 1909. This amount represents one-fourth of the concrete estimated required to complete these Locks, and one-ninth of the concrete estimated necessary to complete all the Locks in the Canal.

It was at one time planned to start concrete laying in the Gatun Locks on Jan. 1, 1909, and the estimate of future output prepared as of that date indicated that there should be 600,000 cu. yds. in place by July 1, 1910. Through delays in installation, the entire handling plant was not ready for operation until the latter part of Aug., 1909, nearly eight months later, but notwithstanding, the work on July 1 was less than 87,000 cu. yds., behind the original estimate. With the plant working as smoothly as it has during the past few months, it is quite possible that all the earlier estimates as to production will be exceeded by Jan. 1, 1911.

Up to July 1, the plant had been in operation for a total of 267 days, including six Sundays. Work was carried on every day during the month of Oct., 1909, and a part of the plant was in operation one Sunday in March this year. Each month has shown a steady increase in output, and there has been a corresponding increase in the daily average output for each month, with one exception that of March, when the daily average fell below that of February, caused principally by the inclusion of a Sunday on which day only a small amount of concrete was laid.

The month of June surpassed all previous records for the total, as well as average daily output, and but for lightning striking the pumping station and shutting off water supply, the June record would have exceeded 90,000 cu. yds. On two days, the total nearly reached the 4,000 cu. yd. mark; on June 6, when it fell two yards short, and again on June 30, when the mark was missed by 11 yards.

Five-eighths of the concrete in the entire upper lock at Gatun is now in place. Work has already been started on the floor and lateral culverts of the middle lock and as the floor is only three feet in thickness, it is proceeding rapidly. Concrete for the operation at that point is being supplied from the auxiliary mixer by trains of dump cars, operating on a trestle over the south head wall and thence on down the center of the upper lock into the middle lock. Steam shovel excavation in the latter lock has been concluded, and the necessary cleaning up will be accomplished by hand and locomotive crane.

The total output of concrete, the daily average, and the number of days worked, by months, from August, 1909, to June 1910, inclusive, is as follows:

1909	Quantity.	Daily Average.	Days Worked.
August	1,298	185½	7
September	11,934	459	26
October	29,378	948	*31
November	30,384	1,266	24
December	43,478	1,672	26
1910			
January	53,034	2,121	25
February	57,605	2,400	24
March	59,831	2,216	†27
April	63,036	2,424	26
May	74,162½	2,966½	25
June	89,239½	3,432	26
Totals	513,380	1,923	267

*Five Sundays worked. †One Sunday worked.

A total of 21,398 cu. yds. was laid in the locks during the week ending July 2, an average of 3,566 cu. yds. a day, which is the highest daily average for any week up to this time. The record by days follows:

	Cubic yards.			
	Construction plant.	Auxiliary plant.	Large stone.	Total.
June 27	2,128	890	183	3,201
June 28	2,456	1,166	303	3,925
June 29	2,558	1,161	270	3,989
June 30	2,514	834	230	3,578
July 1	2,280	900	182	3,362
July 2	2,236	848	259	3,343
Total	14,172	5,799	1,427	21,398
Previously reported				498,687
Grand total				520,085

In addition, a total of 556 cubic yards of concrete was laid in the spillway of Gatun dam during the week.

*"Canal Record," July 6, 1910.

EXTENSIVE FOREST FIRES were reported last week in western Montana. Many of the fires were in the National forest reserves.

IN A COLLISION AT RICHMOND, ENGLAND, July 17, the Brighton express was wrecked and eight persons were killed, 30 others being injured. The express collided with another train which was standing at the station.

A MONORAIL CAR WAS DERAILED July 16 on the Pelham Park & City Island Monorail Ry., the new line between City Island and Bartow, N. Y. Several of the 100 passengers on the car were severely injured. The wrecked car was the first one run over the new line with passengers aboard, although previous runs had been made carrying only officials of the company. The accident occurred at a curve. It is not made clear, in press reports, whether the balancing rails or the monorail track first gave way. The railway is of the type invented by Mr. Howard Tunis, in which guide wheels are attached to suitable frames on the roof of the car and balance it by pressing laterally against the guide rails.

TWO DYNAMITE ATTACKS ON BRIDGES occurred within the past fortnight. At Jersey City, N. J., during the night of July 8 to July 9, a steel viaduct being built by the Phoenix Construction Co. for the Lehigh Valley Ry. was damaged by two explosions at the footings of two posts. The footings and the adjoining steel members were extensively damaged but the rest of the viaduct was not harmed. At Pittsburg, Pa., early on the morning of July 15 an explosion was set off under a bridge just completed for the West Side Belt R. R. at West Carson St. by the McClintic-Marshall Construction Co. The bridge was about to be put into service. The damage done is not serious, but the necessary repairs will delay opening the bridge to traffic for some weeks. Both the above attempts are ascribed to hostility of labor-union fanatics, as both contractors work open-shop. The McClintic-Marshall concern has been the object of a dozen or so similar attempts in four or five years, though in no case, fortunately, was the damage very serious.

PITTSBURG WILL PURCHASE A TOLL BRIDGE if the plans of the city authorities for immediate action go through. It was decided jointly by city and county a few days ago to institute condemnation proceedings against the Seventh Street bridge over the Allegheny River. For some years there has been a strong sentiment for "freeing" the Allegheny River bridges, most of which are owned by private companies. The large bridges at Sixth St. and Seventh St. are the chief objects of this movement; the present action if carried out will be the first realization of the "freeing" plans, except for the removal of the privately-owned Point Bridge two years ago.

THE CANALIZATION OF THE HUDSON from Waterford south to Albany is to be undertaken by the federal government, under provision of the recently signed river and harbor bill. The new Barge Canal terminates at Waterford, on the Hudson above the Troy dam, whereas the old Erie Canal had its terminus at Albany, below that dam. It therefore became necessary that a proper channel be made from Albany up to Waterford in order to give the barge Canal the proper outlet to the lower

river. This portion of the canal system has been neglected by both state and federal authorities up till the present, although the state of New York has repeatedly tried to have the United States assume the responsibility of the work.

THE U. S. GEOLOGICAL SURVEY has been given a total appropriation of $1,175,040 for the fiscal year ending June 30, 1911. This is $232,350 less than the amount appropriated for the Survey for the fiscal year 1910, but the work of analyzing and testing fuels and the investigations of the causes of mine accidents were transferred from the Survey to the newly created Bureau of Mines, and the tests of structural materials were transferred from the Survey to the Bureau of Standards, with consequent transfer of appropriations. An increase of $75,000 was made in the appropriation for geological work and of $50,000 for stream gaging.

TWO CEMENT SHOWS are to be held next winter, one at Chicago as has been the custom for some years past, and the other in Madison Square Garden, New York. The New York show is to be Dec. 17-23, 1910, and, it is reported, will be held in conjunction with the annual meeting of the National Association of Cement Users, though that association has not as yet made official announcement of the fact. The Chicago show will be held, as usual, in the Coliseum, and will last from Feb. 17-23, 1911.

THE GRAND TRUNK RAILWAY expects to enter Providence, R. I., by means of an extension from Palmer, Mass., through Massachusetts and Rhode Island. The necessary permission from the Massachusetts Railroad Commission was granted on July 12. Authorization on the part of Rhode Island was secured some time ago.

SKELETON MASTS NOT SATISFACTORY.—The Navy Department is dissatisfied with the woven wire masts with which some 15 or 18 of our battleships were equipped last year and which attracted so much attention when they were in this harbor last fall during the Hudson-Fulton celebration. These masts were installed at an expense of $10,000 each, and the fact that so many ships were fitted with them before they had been thoroughly tried out in one or two vessels seems to evidence lack of foresight. The most serious drawback to this innovation is that on account of the altitude of the platform at the top there is an appreciable amount of vibration at certain speeds, and besides, the system of observation, calculation, and communication is thereby a complicated one.—"Marine Journal," July 16, 1910.

FIRE DESTROYED PIER 14, North River, New York City, on Saturday afternoon, July 16. Formerly occupied by the Red Star Line of Trans-Atlantic steamships, the pier had been for the past few weeks in the hands of the Metropolitan Line, which operates the oil-burning turbine steamers "Yale" and "Harvard" between New York and Boston. When the fire broke out, at about 12.30 o'clock, the "Harvard" was in her place at the south side of the pier. Steam was hastily gotten up and the vessel escaped under her own steam with no further damage than a scorching of the paint on the side toward the pier.

The freight steamer "H. F. Dimock" on the north side of the pier caught fire and lost her deck work and most of the paint from her hull before she was rescued by tugs. Three men of the "Dimock's" crew lost their lives. Eight freight barges with their contents were burned between Piers 14 and 15.

The whole of the superstructure of Pier 14, with its corrugated iron walls and steel framework, was reduced to a heap of ruins.

Personals.

Mr. H. B. Pearson, Jr., has been appointed City Engineer of El Centro, Cal.

Mr. J. W. English has resigned his position as President of the Atlanta & Carolina Electric Ry.

Mr. W. K. Vanderbilt, Jr., has become Assistant to the President of the New York Central & Hudson River R. R. and the Cleveland, Cincinnati, Chicago & St. Louis Ry.

Mr. E. D. Vincent, M. Am. Soc. C. E., has resigned from the U. S. Reclamation Service to become Assistant Chief Engineer of the Los Angeles Bureau of Harbor Improvements.

Mr. Charles G. Armstrong has been appointed a consulting engineer in the Department of Bridges of New York City at a salary of $7,500 a year. He will be assigned to supervising work in the construction of the new Municipal Building.

Mr. H. Ross Callaway, recently an assistant to the Mechanical Engineer of the New York Edison Co., has joined the staff of Mr. Walter B. Snow, publicity engineer, of Boston, Mass. Mr. Callaway is a graduate of the Massachusetts Institute of Technology.

Mr. L. M. Pomeroy, Assoc. M. Am. Soc. C. E., for the past two years Assistant to the President of the Safety Car Heating & Lighting Co., has become Chief Engineer of the railway and industrial division of J. G. White & Co., incorporated, with headquarters in New York City.

Mr. J. W. Beardsley, M. Am. Soc. C. E., has resigned his position with J. G. White & Co., engineers and contractors, to take charge of irrigation work for the Government of Porto Rico. He was for seven years Director of Public Works of the Philippine Islands.

Mr. H. B. Nichols, Engineer of Way of the Philadelphia Rapid Transit Co., has been appointed Chief Engineer to succeed Mr. W. S. Twining, whose resignation was noted in our issue of May 26. Mr. Geo. B. Taylor, Assistant Engineer of Way, has been promoted to succeed Mr. Nichols.

Mr. D. M. Fraser, District Engineer on location and construction of the Canton-Kowloon Ry., Imperial Chinese Rys., for the past three years, has been appointed Chief Engineer in charge of location of the Federated Malay States Ry. Mr. Fraser is the author of the articles on "Railway Location in Victoria, Australia," published in Engineering News in 1904. His headquarters at present are at Seremban, Federated Malay States.

Lieut.-Com. Richard M. Watt, U. S. N., at present senior construction officer at the Norfolk Navy Yard, has been chosen to succeed Rear-Admiral Washington L. Capps as Chief Constructor and Chief of the Bureau of Construction and Repair. The resignation of Rear-Admiral Capps, noted in our issue of July 14, has been accepted, to take effect on Oct. 1, 1910, when he will have completed 30 years of service.

Obituary.

James B. Faulks, Jr., Jun. Am. Soc. M. E., Associate Professor in the college of engineering of Syracuse University, died at Syracuse, N. Y., July 15, from typhoid fever. He was 38 years old and was a graduate of Stevens Institute of Technology.

August Forsberg, who was for several years City Engineer of Lynchburg, Va., died July 15 at his home in that place at the age of 79 years. Mr. Forsberg was a native of Sweden, but had resided in Lynchburg for nearly 50 years. He served in the Confederate Army during the Civil War and attained the rank of colonel.

Silas G. Comfort, Assoc. M. Am. Soc. C. E., Vice-President and Professor of Engineering of Pennsylvania Military College at Chester, Pa., was found dead July 13 in the shallow waters of a small creek near Chester. His death is regarded by the coroner as accidental. Prof. Comfort graduated at Syracuse University in 1884 and went to Chester, Pa., the same year as an instructor in mechanical drawing at Pennsylvania Military College. He became head of the department of civil engineering in 1892 and was elected Vice-President of the college in 1894. About one week before his death he had been appointed Consulting Engineer for the City of Chester to advise in regard to new sewers, paving and water supply.

Cornelius H. Ackerman, a contractor and civil engineer, died July 1 at the home of his son in Binghamton, N. Y. Mr. Ackerman was born at Allendale, N. J., in 1839. In the Civil War, he was employed in the commissary department and the secret service. Shortly after the war, and after a brief period spent in the Pennsylvania oil fields, he became interested on construction work.

He took up the study of architecture, but found the confinement of office work unhealthful and in 1870 entered the building and contracting business. While associated with the late John Evans, he built portions of the New York, Ontario & Western R. R. and the South Pennsylvania Ry. Later he became Vice-President of the Crary Construction Co., of Binghamton, N. Y., which held extensive contracts for construction work on the New York, Ontario & Western and the Lake Shore & Michigan Southern Rys. At the time of his death Mr. Ackerman was interested as a capitalist in numerous enterprises. His son, Mr. Robert McK. Ackerman, of Binghamto.., survives.

John Denison Evarts Duncan, Managing Engineer for the past six years of the New York office of the firm of Sanderson & Porter, engineers and contractors, died at Ann Arbor, Mich., July 13, at the home of his mother, Mrs. Martha Duncan.

When taken ill Mr. Duncan was returning from a business trip of investigation and inspection in the West, where he had gone to examine electrical properties for which his firm is acting as consulting and constructing engineers.

He was born at Union Falls, Clinton Co., N. Y., in July, 1871, and, with his parents, moved to Ann Arbor, Mich., in 1879, where he lived until the completion of his technical education. His preparation for his university course was received in the Ann Arbor High School, from which he graduated in 1889. He was graduated from the University of Michigan in 1893, receiving the degree of Bachelor of Science in mechanical engineering. The following year was spent in post-graduate work at Cornell University, from which he received the master's degree in mechanical engineering in 1894.

From 1894 to 1896 Mr. Duncan was employed by the Terre Haute Street Ry. Co., Terre Haute, Ind., and the Stanley Electric Manufacturing Co., of Pittsfield, Mass. With the latter company, he was associated with Mr. Stanley and Mr. Chesney in their extensive experimental work connected with the solving of the early high-tension problems, which were studied and worked out at their factory. On leaving the Stanley Electric Manufacturing Co., Mr. Duncan successively held engineering positions in New York with the Metropolitan Street Ry. Co., Western Electric Co., New York Telephone Co., Westinghouse, Church, Kerr & Co., and Consolidated Railway, Electric Lighting & Equipment Co.

Upon his return to New York City from a trip to Alaska on engineering work connected with a mining enterprise, Mr. Duncan entered the employ of Sanderson & Porter. While directing the engineering work of this firm, he was in responsible charge of the design and execution of many large and diversified engineering projects and earned the high esteem and confidence of his employers, associates and friends in engineering and business circles.

Mr. Duncan was a Life Member of the American Society of Mechanical Engineers, an Associate of the American Institute of Electrical Engineers, member of the Brooklyn Engineers' Club, the Engineers' Club of New York, the Machinery Club of the City of New York, the Masons, the Michigan Club of New York, the University of Michigan Club, and the Cornell University Club. In 1901, Mr. Duncan married Miss Lena Hill, of Lyons, N. Y., who, with his mother and two brothers, survives him.

Engineering Societies.

COMING MEETINGS.

OHIO ELECTRIC LIGHT ASSOCIATION.
July 26-28. Annual convention at Cedar Point, Ohio. Secy., D. L. Gaskill, Greenville, Ohio.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
July 26-29. Joint meeting with the British Institution of Mechanical Engineers at Birmingham and London, England. Secy., Calvin W. Rice, 29 West 39th St., New York City.

NATIONAL GOOD ROADS ASSOCIATION.
July 28-30. Annual meeting at Niagara Falls, N. Y. Secy., A. M. Grady, Chicago Opera House Bldg., Chicago, Ill.

TRAVELING ENGINEERS' ASSOCIATION.
Aug. 16-19. Annual convention at Niagara Falls, Canada. Secy., W. O. Thompson, New York Central Car Shops, East Buffalo, N. Y.

LEAGUE OF AMERICAN MUNICIPALITIES.
Aug. 23-26. Annual convention at St. Paul, Minn. Secy., John MacVicar, Des Moines, Iowa.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Sept. 5-9. Annual meeting at Milwaukee, Wis. Secy., W. C. Woodward, Washington, D. C.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES.
Sept. 6-8. Annual meeting at Thousand Islands, N. Y. Asst. Secy., Walter Neumuller, 55 Duane St., New York City.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Sept. 6-9. Annual convention at Rochester, N. Y. Secy., Frank P. Foster, Corning, N. Y.

MICHIGAN GAS ASSOCIATION.
Sept. 8-12. Annual meeting on board steamer sailing from Detroit, Mich. Secy., Glenn R. Chamberlain, Grand Rapids Gas Light Co., Grand Rapids, Mich.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 13-16. Annual convention at St. Louis, Mo. Secy., A. P. Dane, Reading, Mass.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION.
Sept. 21-23. Annual convention at Colorado Springs. Secy., J. C. Lawler, P. O. Box 938, Colorado Springs.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 21-23. Annual convention at Rochester, N. Y. Secy., Willard Kent, Narragansett Pier, R. I.

NATIONAL IRRIGATION CONGRESS.
Sept. 26-30. Annual meeting at Pueblo, Colo. Secy., Arthur Hooker, Pueblo, Colo.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—A party of 160 members and guests sailed on the steamer "Celtic" from New York City July 16 to attend the joint meeting with the Institution of Mechanical Engineers. It is expected that they will be joined in England by about 100 other members and guests already in Europe. Papers to be presented at the joint meeting will include papers on the electrification of railways, by President George Westinghouse, L. R. Pomeroy and Wm. B. Potter; on handling locomotives at terminals, by Frederic M. Whyte, H. H. Vaughan, F. H. Clark and Wm. Forsyth; and a paper on involute gearing by Wilfred Lewis. A symposium on high-speed tool practice will be contributed by leading American manufacturers.